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« ETUDE DE LA COLLABORATION DANS LES ENVIRONNEMENTS VIRTUELS 3D ET DE L'IMPACT DE LEUR UTILISATION SUR LA PERFORMANCE DES EQUIPES: ENTRE MANAGEMENT ET CONCEPTION DES SYSTEMES D'INFORMATION»

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"Research is to see what everybody else has seen, and to think what nobody else has thought."

Albert Szent-Gyorgyi[1] (1893-1986)

[1] Hungarian, 1937 Nobel Prize for Medicine.

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"*Keep away from people who try to belittle your ambitions. Small people always do that but the really great make you feel that you too can become great.*"

Mark Twain[2] (1835-1910)

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Ikram Bououd

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ABSTRACT

Collaboration is increasingly distributed and influenced by the technologies involved in the workspace. 3D Virtual worlds (VWs) are rich, highly interactive and promising collaboration tools providing a more realistic visual dimension in representing work environment and a growing capacity of simulation. Thanks to avatars (representation of their users), they may reinvent the notion of co-presence (the being together) and provide rich social interactions. Several researchers and practitioners are particularly interested in the potential of these new media to support collaborative practices. However, the literature does not provide yet satisfactory and accurate response to companies about impacts of these technologies' use on team performance. Existent researchers studied specific factors influencing collaboration. A research model gathering determinants of three different categories (technological, individual and collective) impacting team performance has never been proposed. This research attempts to address this gap and looks at this effect more closely. From a methodological point of view, our methodology is based on the Hevner's and colleagues (2004) IS research framework combining behavioral science and design science. From the behavioral science side, qualitative and quantitative studies have been conducted. We report on the impacts of a set of important determinants that influence team performance. This research describes inner IT dynamics distinguishing these new media. It research highlighted determinants that are fostering collaboration such knowledge sharing, knowledge application, cognitive absorption, virtual co-presence, VW technology usage, customization, and object manipulation. Others determinants are found to inhibit collaboration in 3D VWs such as social loafing and density. From a design science side, we designed a serious game focusing on the determinants mentioned above and could be useful to vary collaborative scenarios in the aim to deepen the study of collaboration in 3D VWs and enhance team performance. This game aims at bringing a learning-by-doing experience to explore the specificities of team collaboration in VWs. This research argues that successful collaboration is possible in VWs with the respect of a set of best practices.

KEY WORDS

Team collaboration, Virtual teams, Virtual Worlds, Performance, Serious Games, Collaborative scenarios.

RESUME

Les sociétés modernes sont confrontées à plusieurs contraintes comme les forces économiques, les pressions concurrentielles et les progrès technologiques. Elles ont créé et innové des outils de gestion afin de maintenir et améliorer leur performance (Wang and Haggerty, 2009). Dans le contexte complexe et non - stable de la mondialisation et de l'ouverture de marchés, l'évolution devient un défi. Ainsi, la collaboration est devenue un atout important pour les organisations qui souhaitent tirer profit de l'intelligence collective et maximiser leur productivités (Drucker, 1989; Nunamaker et al 1998; Nunamaker et al 2002). Selon Kock (2008), la collaboration efficace est l'une des clés de réussite et un avantage concurrentiel des organisations d'aujourd'hui car elle permet une meilleure évolution et améliore le développement (Kock, 2008). De nos jours, la collaboration est devenue de plus en plus distribuée et virtuelle, influencée par les technologies utilisées dans le milieu de travail. Griffith et ses collègues (2003) affirment que la technologie peut ouvrir des nouvelles opportunités pour les équipes et les rendre plus efficaces. De plus, McGrath et Berdahl (1998) ont démontré que la technologie peut fournir un moyen pour structurer le travail de l'équipe et améliorer l'information disponible pour les membres, ainsi qu'elle peut leur fournir un système de communication (McGrath and Berdahl 1998).

Les environnements virtuels (VWs) sont des environnements virtuels 3D où les utilisateurs interagissent via des avatars. Ils sont considérés comme des outils collaboratifs prometteurs offrant des environnements riches et interactifs. Selon Davis et ses collègues (2009), ces environnements offrent aux membres de l'équipe de nouvelles manières pour gérer et surmonter plusieurs obstacles à la collaboration. En outre, ces environnements augmentent l'apprentissage axé sur le groupe (Suh and Lee 2005) et l'engagement dans les processus (Franceschi et al 2009). Ils ont le potentiel pour une collaboration plus riche et engageante (Davis et al. 2009). En effet, Kock (2008) considère la collaboration comme un thème clé dans les usages organisationnels des environnements virtuels 3D.

Ces VWs sont définis comme des «environnements virtuels artificiels intégrant des représentations d'éléments du monde réel comme les êtres humains, les paysages et d'autres objets» (Kock, 2008, p 1). Ils ont évolué de chambres de

bavardage à des communautés virtuelles qui comprennent des espaces personnels, des affaires (Nah et al 2010), des actions collaboratives (Kock, 2008; Nah et al. 2009) et le V-learning (Chen et al. 2009; Davis and Zigurs 2008).

VWs s'inscrivent dans la tendance 3D qui touche l'Internet, la télévision, les jeux sérieux, etc. En suivant cette nouvelle tendance, ils présentent des environnements adéquats offrant de nouvelles formes de collaboration et d'interaction sociale (McKenna et al. 2010). En outre, dans le domaine des affaires, VWs sont considérées comme un moyen novateur de collaboration et de partage des connaissances au sein des organisations (Chandra et al. 2009). Par conséquent, VWs offrent un fort potentiel pour soutenir les pratiques collaboratives et constituent une alternative supplémentaire pour les situations de travail collectif (Davis et al. 2009), la prise de décision, la gestion de projet virtuel (Owens et al. 2009) et l'apprentissage virtuel (Davis and Zigurs 2008).

Owens et ses collègues (2009) ont montré que les VWs «*impactent les pratiques organisationnelles et impactent la gestion de projet virtuel (VWPM*)» (Owens et al. 2009, p.34). Ils ont affirmé que les VWs pourraient améliorer la collaboration et la gestion de projet virtuel (VWPM) par le biais des capacités technologiques uniques qu'ils fournissent. En effet, en utilisant les capacités de cette nouvelle technologie, les équipes virtuelles ont accès à des environnements efficaces, riches et engageants ce qui aide à surmonter les obstacles à la collaboration.

Ces atouts ont été à l'origine de la motivation et de l'intérêt remarquable à cette technologie par plusieurs sociétés de renommée internationale telles que IBM, Nike, DELL, la NASA, BNP, etc. Ces entreprises, entre autres, ont lancé leurs propres territoires sur Second Life, l'un des environnements virtuels les plus connus. Des entreprises telles que Schneider Electric et IBM ont également mené des projets de collaboration inter organisationnels dans Second Life pour combiner leurs forces et capitaliser sur un partenariat mutuellement bénéfique. En outre, de nombreuses entreprises telles que Cisco et IBM encouragent la collaboration dans les VWs en recueillant leurs employés, partenaires et clients sur leurs îles de Second Life (Hendaoui et al. 2008). En effet, les sociétés précitées considèrent les VWs comme un outil de travail pour l'interaction, la communication, la socialisation, la collaboration et la gestion de projet. Par

conséquent, il ya une hausse de la nature virtuelle dans le travail d'équipe, une sorte de collaboration virtuelle qui s'installe.

Les travaux de Vreede et ses collègues (2009) s'intéressent à la pratique de la collaboration et ont développé un cadre décrivant ses différentes composantes à savoir : l'être humain, la technologie, la facilitation, l'information et le processus. Ils ont souligné que ces cinq caractéristiques restent les mêmes, même si les pratiques de collaboration ont évolué au fil du temps de face-à-face au écran - à - écran vers les 3D virtuels (VWs). Étant donné que ces éléments s'influencent mutuellement, l'introduction d'une nouvelle technologie à la pratique de collaboration aurait un impact sur les quatre composantes restantes. Dans ce nouveau contexte de VWs, l'être humain est un composant qui est impacté à deux niveaux différents, le niveau individuel et collectif. De plus, la facilitation peut devenir plus complexe dans ces nouveaux environnements à cause du manque de contact visuel et des émotions. Le composant information pourrait être influencé en termes de gestion d'apprentissage et d'application des connaissances. Dans cette thèse, nous allons essayer de clarifier l'impact de cette nouvelle technologie sur la collaboration et la performance de l'équipe.

Avec l'émergence d'un tel espace de travail dynamique et ludique, les gens peuvent mener leurs activités en temps réel en n'importe quel point de la planète. L'utilisation efficace et efficiente des VWs comme plate-forme collaborative peut donner lieu à une variété d'avantages pour une organisation allant de la réduction des coûts d'exploitation (par exemple, voyages, temps de travail perdu en raison des réunions), à l'amélioration de la productivité (par exemple, la vitesse et la richesse de la collaboration, la créativité) (Wang and Haggerty, 2009).

En fait, un rapport réalisé par Erica Driver et ses collègues (2008) de Forrester Research, Inc. a prédit qu'entre 2013 et 2015, les VWs et l'Internet 3D seront aussi importants pour les organisations comme ce qui est pour le Web aujourd'hui. Cette équipe de recherche a également recommandé que les organisations commencent à établir une présence dans les VWs populaires. Sans aucun doute, les entreprises peuvent bénéficier du potentiel de marketing disponible sur les VWs, mais aussi elles peuvent renforcer leurs fonctions essentielles telles que la collaboration à distance, la formation du personnel, et la construction et le partage des objets 3D / artefacts (Driver et al. 2008).

Récemment les experts ont fait écho aux affirmations de Driver et ses collègues (2008), ce qui suggère que les capacités collaboratives inhérentes aux VWs vont changer notre manière d'interaction sur le Web en 2015 (Gaudin 2010). Notamment, cela ne signifie pas que les technologies de collaboration de nos jours (par exemple, la vidéoconférence, le message texte et les systèmes de soutien de groupe (GSS)) seront obsolètes, mais plutôt, les technologies pertinentes seront intégrées dans les VWs (Driver et al 2008). Le succès de la collaboration dans les environnements virtuels sera subordonné à notre capacité à reproduire les activités du monde réel dans les VWs comme la collaboration à distance. Cette activité est supposée donner lieu au développement une part très importante des affaires et à des implications sociales conséquentes (Bulkeley 2007; Driver et al. 2008; Kharif 2007). VWs offrent les avantages traditionnels de la communication en ligne (pratique, efficace, permet la communication synchrone pour les membres de l'équipe virtuelle, et réduit les coûts de voyage). En outre, les VWs ajoutent de la valeur au processus de collaboration virtuelle parce qu'ils offrent une dimension visuelle, orale et spatiale aux communications électroniques (Kahai et al 2007; Kharif 2007).

Depuis les années 80, la notion de virtualité a souvent intéressé les chercheurs en systèmes d'information (et plus généralement en sciences de gestion) (Chudoba et al 2005; Griffith et al. 2003; Martins et al 2004). Ils ont étudié l'émergence et le développement d'organisations virtuelles (équipes, communautés, entreprises) (Ahuja and Carley 1999; Armstrong and Hagel, 1996; Boughzala 2001; Boughzala 2007; Giddens, 1984 ; Shaw 1971). Les principales contributions se concentrent sur les possibilités que les progrès technologiques, liés à l'information et la communication, offrent aux entreprises en termes d'activités, de collaboration, d'apprentissage organisationnel, de création de valeur, d'innovation, etc. Depuis le début des années 2000, des recherches ont commencé à explorer la contribution des environnements virtuels comme un espace d'interaction sociale et un outil pour organiser, faciliter et diriger des collaborations (Davis and Zigurs 2008). Ainsi, plusieurs facteurs clés qui ont une influence sur la collaboration ont été considérés. Nous citons: l'immersion (Guadagno et al 2007), la co - présence (Biocca et al 2003; Slater et al 2000), la manipulation de objets (Robinett and Holloway, 1992), la complexité des tâches (Nah et 2009; Nah et al. 2011);

l'absorption cognitive (Agarwal and Karahanna 2000), etc. En plus déterminants classiques de collaboration l'objectif commun (Johnson et al. 2002 ; Zigurs 2003), la confiance, le partage des connaissances (Cramton 2001), paresse sociale (George, 1992; George, 1995), la traçabilité des échanges (Briggs and Vreede 2005), la facilité d'utilisation de le technologie (Chedmaila et al. 2002), le degré de virtualité (Martins et al. 2004), le leadership (Munkvold and Zigurs 2007), etc.

VWs 3D possèdent des atouts importants provenant de leur conception en 3D qui fait d'eux une métaphore du monde réel et permet une expérience plus interactive et attirante (Davis et al. 2009). Sans doute, les avantages et les opportunités fournies par cette technologie apportent un plus pour les équipes virtuelles mais l'impact de son utilisation sur la collaboration et la performance de l'équipe n'a pas été étudié.

Selon Wasko et ses collègues (2011), en observant les avantages globaux de la collaboration dans les VWs, il ya une demande croissante des entreprises multinationales à implémenter des VWs 3D afin d'améliorer leurs processus de travail (Wasko et al. 2011). Néanmoins, l'utilisation de cette technologie dans les milieux professionnels est encore entourée de beaucoup de prudence et ses capacités n'ont pas été profondément explorées par la littérature (Davis et al. 2009). En fait, la recherche doit informer et aider les organisations à comprendre les avantages et les inconvénients de cette technologie afin de pouvoir profiter au mieux de ses atouts (Wasko et al. 2011).

Il est nécessaire de développer une compréhension théorique de l'adéquation entre les tâches de collaboration et les capacités des VWs (Boughzala et al. 2012). Les recherches qui ont examiné ce type de collaboration et ont proposé des modèles de recherche. Cependant, ces recherches sont centrées sur l'individu, donc il ya un manque de recherches ciblant les trois niveaux ensemble individuel, collectif et technologique de ce genre de collaboration.

Question de recherche

Notre thèse est inscrite dans ce champ de recherche. En un premier temps, l'objectif principal est d'étudier la collaboration dans les environnements virtuels 3D et l'impact de leur l'utilisation sur la performance de l'équipe. Ensuite, il s'agit de proposer une manière pour améliorer la collaboration dans ces environnements.

Plusieurs équipes de recherche ont étudié la collaboration dans les environnements virtuels 3D (Venkatesh et Windeler 2012), nous citons quelques références (Bergin et al 2010; Cahalane et al 2010; Chandra et al 2012; Davis et al. 2009; Goh and Yoon 2010; Goh and Wasko 2010; Hassell et al. 2009; Hendaoui et al. 2008; McKenna et al. 2010; Meyer and Swatman 2009; Venkatesh and Windeler 2012) Cependant, très peu de ces recherches ont tenté d'évaluer l'impact de l'utilisation des environnements virtuels dans l'espace de travail sur la collaboration et la performance de l'équipe. Aucun de ces recherches n'a donné une réponse satisfaisante qui tient compte des trois niveaux individuel, collectif et technologique Les chercheurs ont étudié les facteurs qui influencent la collaboration en utilisant des approches qualitatives et quantitatives. Cependant, plusieurs facteurs importants n'ont pas été étudiés tels que le partage des connaissances, la paresse sociale, la manipulation des objets, etc. En effet, l'utilisation de ces technologies dans le lieu de travail nécessite l'étude des différents déterminants afin d'apporter des réponses concrètes aux entreprises, qui souhaitent utiliser ce type de technologie, sur leur impact sur la collaboration et la performance de l'équipe.

Dans cette recherche, nous essayons de répondre à la question suivante :

Comment utiliser les environnements virtuels 3D pour qu'ils améliorent la performance de l'équipe ?

Cette question de recherche peut être divisée en quatre sous questions:

• Quels sont les déterminants de la collaboration dans les environnements virtuels 3D ?

• Y a t-il une différence entre les médias classiques et les environnements virtuels 3D pour supporter les activités collaboratives ?

• Quel est l'impact des caractéristiques spécifiques de environnements virtuels 3D sur la performance individuelle et collective ?

• Comment peut-on améliorer la collaboration dans les environnements virtuels 3D ?

Plan

Revue de la littérature

Chapitre I

Ce chapitre présente une revue de la littérature sur les environnements virtuels et les jeux sérieux et leur utilisation dans des fins sérieuses.

Chapitre II

Ce chapitre fournie une revue de littérature sur la collaboration dans les équipes virtuelles et dans les environnements virtuels 3D.

Cadre méthodologique et théories

Chapitre III

Ce chapitre présente une revue de la littérature sur les théories liées au sujet de la recherche et leur importance pour notre étude.

Chapitre IV

Ce chapitre présente notre cadre méthodologique et explique l'importance de chaque étude pour répondre à la lacune de recherche et au besoin métier.

Etudes de cas et expérimentations

Chapitre V

Ce chapitre présente notre étude exploratoire des environnements virtuels 3D.

Chapitre VI

Ce chapitre étudie l'impact de l'utilisation des environnements virtuels 3D (Second Life) sur la performance de l'équipe en la comparant au contre part traditionnel (Skype).

Chapitre VII

Ce chapitre a porté sur une étude de terrain avec des professionnels qui utilisent les environnements virtuels 3D dans leurs lieux de travail.

Chapitre VIII

Ce chapitre présente la conception et le processus d'évaluation d'un nouveau jeu sérieux présentant un ensemble de scénarios de collaboration pour les membres de l'équipe et pour les managers.

Chapitre IX

Ce chapitre présente le résumé des résultats apportés par les différentes études tout en se référant aux objectifs de cette thèse.

Tâches à accomplir

Cette recherche tente de répondre à une lacune de la recherche et un besoin métier :

- Nous essayons de répondre à la lacune de recherche par l'identification, la classification et l'étude des déterminants pertinents qui caractérisent la collaboration dans les environnements virtuels 3D dans le but de comprendre leur impact sur la performance de l'équipe. Par conséquent, les objectifs pour répondre à la lacune de la recherche sont les suivants :

1. Identification les déterminants qui caractérisent la collaboration dans les environnements virtuels 3D qui n'ont pas été étudiés par la littérature.
2. Classification de ces déterminants en trois catégories à savoir : technologiques, individuels et collectifs. Cela sert à avoir un paysage plus complet de l'ensemble des déterminants impactant la collaboration.
3. Étude de l'impact de l'utilisation de ces environnements sur la performance de l'équipe.

⇨ Mise en place des modèles de recherche permettant une meilleure compréhension de l'impact des environnements virtuels sur la performance de l'équipe.

- Nous essayons de répondre au besoin métier des entreprises sur l'utilisation des environnements virtuels au milieu de travail en fournissant un ensemble de scénarios collaboratifs permettant aux utilisateurs de comprendre la particularité de la collaboration dans ces environnements et ainsi d'améliorer la performance. De plus nous fournissons une liste de bonnes pratiques pour collaborer dans ces environnements. Les objectifs pour répondre au besoin métier sont les suivants :

1. Comprendre la particularité de la collaboration dans ces environnements virtuels en tenant compte des déterminants que nous avons considérés.

2. Découvrir les bonnes pratiques à suivre quand on utilise les environnements virtuels comme plateforme pour la collaboration dans l'espace de travail.

⇨ Concevoir des scénarios de collaboration (Serious Game) permettant aux utilisateurs d'améliorer la collaboration dans les environnements virtuels 3D.

Cadre méthodologique

Partant d'une base riche de théories de la littérature, cette étude a mis en relief une variété d'entre elles dans le but de comprendre l'importance des capacités de la technologie et des interactions sociales dans le travail d'équipe. La théorie de la présence sociale, la théorie de la richesse des médias, la théorie de la synchronicité des médias et la théorie de convenance entre tâche-technologie ont été d'une forte influence sur cette recherche du côté de la science de comportement. En outre, la théorie de l'apprentissage par l'expérience, la théorie sociale cognitive et la théorie de l'autodétermination étaient pertinentes pour intégrer une expérience d'apprentissage par la pratique lors de l'élaboration des scénarios collaboratifs.

D'un point de vue méthodologique, cette thèse est basée sur le Framework de recherche de Hevner et ses collègues (2004) combinant la science de comportement et la science de conception. Nous avons élaboré un cadre méthodologique visant à apporter une méthode pour répondre à la fois au besoin métier et à la lacune de recherche mentionnés plus haut. Ce cadre contient plusieurs itérations entre la science du comportement (méthode qualitative et quantitative) et de la science de la conception (conception des scénarios collaboratifs).

Du côté de la science du comportement, des modèles de recherche qui caractérisent la collaboration dans les VWs ont été établis. Ensuite, des études exploratoires et empiriques ont été menées mixant entre méthodes qualitatives et quantitatives. Du côté de la science de conception, en se basant sur les déterminants des modèles de recherche établis, nous avons conçus un ensemble de scénarios de collaboration visant à faciliter l'étude longitudinale de la

collaboration dans les environnements virtuels 3D. Ces scénarios permettent la variation des situations de collaboration et pourraient être utilisés comme une formation pour les nouveaux utilisateurs de VWs.

Comme ces deux paradigmes (science de comportement et science de conception) sont complémentaires, les scénarios collaboratifs vont se baser sur les résultats des sciences du comportement (se baser sur les déterminants préalablement identifiés). Les modèles de recherche (coté science de comportement) seront renforcées et affinés par les connaissances extraites de ces scénarios de collaboration une fois utilisés par des professionnels.

Enfin, ce cadre souligne deux types de contributions attendues de cette recherche :

- Une contribution théorique en fournissant des modèles de recherche permettant l'étude de la collaboration dans des environnements virtuels en 3D.
- Une contribution pratique en fournissant un ensemble de scénarios de collaboration.

En effet, ce cadre décrit une étude longitudinale de la collaboration dans les environnements virtuels 3D. Dans cette thèse, nous présentons qu'une première itération de ce cadre avec deux modèles de recherche et deux types de scénarios de collaboration (pour manager et pour membre de l'équipe).

Résultats

Dans cette recherche, nous avons atteint les objectifs mentionnés ci-dessus avec plusieurs résultats pertinents. La revue de la littérature et la première étude exploratoire brossent un portrait complet des VW et soulignent leur importance comme une alternative au face à face. Déterminants ont été identifiés et étudiés dans les études quantitatives. Ces études ont apporté une profonde compréhension de l'impact de l'utilisation de VW dans le milieu de travail. Ces études ont montré que les déterminants sélectionnés influencent la collaboration et ont observé leurs effets sur la performance de l'équipe.

Cette étude met en évidence l'impact des atouts de la technologie et le degré auquel les utilisateurs sont à l'aise avec elle. L'exemple de la personnalisation et la manipulation des objets ont été témoin de cet impact par leur influence sur le

partage des connaissances. Par ailleurs, l'importance de l'attitude humaine a également un effet déterminant pour garantir une collaboration réussie dans ces environnements. Par exemple, l'augmentation de nombre des interactions entre membres de l'équipe pourrait rendre la communication floue et compliquée. Au même temps, la présence de paresseux impactera le rendement de toute l'équipe et fera que la productivité baisse. En outre, le partage des connaissances entre les membres et leurs capacités à appliquer ces connaissances partagées ont un impact sur le processus de collaboration sur les deux niveaux individuel et collectif.

La première étude qualitative nous a permis d'étudier les forces, les faiblesses, les opportunités et les menaces des environnements virtuels 3D. Cette étude souligne les atouts de la technologie au même temps. Elle nous a aidé pour filtrer la liste de déterminants.

Nous avons proposé une classification des déterminants après leur sélection. Ils sont classifiés en déterminants inhibiteurs (Densité et paresse sociale) et déterminants favorisant la collaboration (partage de connaissances, absorption cognitive, coprésence, etc.). Nous avons catégorisé les déterminants en trois catégories à savoir : technologique, individuel et collectif. Cette idée nous a permis d'étudier la collaboration sous trois angles au même temps.

Les déterminants peuvent être examinés sous un autre angle. Nous pouvons les classer en trois niveaux d'interaction. A partir de l'être humain, nous identifions l'importance du comportement humain. Ce premier niveau met en évidence l'importance du comportement humain dans le processus de la collaboration. Ici nous identifions la paresse sociale.

Puis, les membres de l'équipe utilisent une technologie (des environnements virtuels en 3D) dans leur lieu de travail, nous identifions le niveau d'interaction homme-machine. Ce niveau contient deux types de déterminants. Des déterminants liés à l'utilisation de la technologie tels que l'application des connaissances, la manipulation d'objets, la personnalisation et utilisation de la technologie. Plus des déterminants liés à l'influence de l'utilisation de la technologie sur l'être humain comme l'absorption cognitive.

Enfin, un troisième niveau collaboration qui apparaît suite aux communications entre membres de l'équipe (exemple, la coprésence, le partage des connaissances).

L'étude comparative entre Second Life et Skype nous a permis de repérer les dynamiques internes de chaque technologie. Nous avons compris l'importance de l'absorption cognitive au sein des environnements virtuels qui permet aux utilisateurs d'être plus engagés sur les tâches qu'ils sont entrain de faire. Au même temps cet effet absorption cognitive peut entrainer une distraction du but de départ derrière l'utilisation des environnements virtuels. Les utilisateurs peuvent perdre leurs temps sur ces environnements ludiques ce qui fait l'importance de créer un compte professionnel pour éviter l'effet de la socialisation avec les amis.

Nous avons développé une nouvelle échelle de mesure pour le déterminant manipulation des objets. Cette échelle nous a aidé à étudier l'effet modérateur que présente ce déterminant sur la relation entre l'utilisation des environnements virtuels et le partage de connaissances.

Nous affirmons que la réussite de la collaboration dépend de plusieurs facteurs de différents types et suivant différents niveaux d'interactions. La réussite de la collaboration est repérée par une bonne performance de l'équipe.

L'utilisation d'un outil pour faire découvrir la collaboration dans les environnements virtuels 3D s'avère important afin de faciliter l'adoption de ces media dans le lieu de travail. Dans cette thèse, nous avons exploité la liste des déterminants que nous avons sélectionnés de la littérature et filtrés à l'aide de l'étude qualitative. Ces déterminants ont servi pour la conception des scénarios collaboratifs. Afin d'améliorer la collaboration, il faut accentuer les déterminants qui sont facilitateurs de la collaboration et diminuer l'effet de ceux qui sont inhibiteurs de la collaboration.

Nous avons fourni la conception d'un jeu sérieux qui tient en compte les spécificités des environnements virtuels. Nous avons développé deux types de scénarios : un pour un membre simple de l'équipe et un type de scénario pour un manager.

Enfin, une collaboration réussie est possible dans les VWs sous réserve de respect d'un ensemble de bonnes pratiques de la collaboration dans ces environnements.

Limites

Cette étude n'est pas sans limites. Tout d'abord, l'implication des d'élèves dans deux études peut limiter la généralisation des résultats de cette recherche. En effet, les élèves sont généralement différents des professionnels et peuvent avoir moins d'expérience avec le domaine. Les étudiants appartiennent la génération numérique et ils sont habitués aux nouvelles technologies. Ce sont des étudiants de management qui sont concernés par la gestion de projet virtuel. La majorité d'entre eux proviennent de la même zone géographique. Cela pourrait introduire un biais régional.

En outre, la deuxième étude quantitative présente également un ensemble de limitations. L'échantillon recueilli principalement sur quatorze environnements virtuels. La majorité des répondants travaillent sur Second Life. Cela pourrait être compréhensible car tous les environnements virtuels impliqués dans l'étude ciblent seulement les professionnels. En outre, la popularité de Second life fait lui le plus visité de ce genre d'environnements virtuels.

Ce travail étudie la collaboration de l'équipe d'une perspective technologique, mais la perspective managériale n'est pas étudiée dans cette recherche. Nous n'avons pas étudié le leadership ni la socialisation dans les environnements virtuels 3D car nous nous avons contenté par la liste sélectionnée lors de la revue de littérature et de la première étude qualitative.

Il ya quelques limitations liées à la conception de serious game. Tout d'abord le jeu est encore en phase de développement. Ensuite, afin de compléter le cadre de l'évaluation de science de conception, des études en laboratoire et des études sur le terrain doivent être menées dans le but d'évaluer le jeu et l'améliorer. Plus tard, et après la première expérience de laboratoire, le jeu devrait être présenté et testé avec des professionnels dans le domaine de la gestion de projet.

Perspectives

Dans cette thèse, nous essayons de mettre des morceaux de connaissances pour comprendre la collaboration dans les environnements virtuels 3D. Ces dernières sont une nouvelle alternative du face -à-face. Nous sommes encore au début, nous espérons mettre notre petite pierre dans ce courant de recherche.

Dans nos prochaines étapes, nous prévoyons établir un nouveau modèle de recherche mixant les deux modèles étudiés dans cette recherche. De nouveaux scénarios peuvent être conçus en vue de prendre en compte de la fusion des deux modèles de recherche.

Le jeu devrait être testé avec les professionnels. Une étude qualitative pourrait être effectuée après ce premier essai dans le but d'obtenir plus de retours. Une troisième étude quantitative pourrait être menée avec les scénarios présentés par le jeu. Nous pourrons varier des variables (sexe, expérience professionnelle, âge, etc.) ce qui peut donner lieu à des résultats plus pertinents. Le jeu pourrait être utilisé plus tard comme outil d'entrainement pour les équipes désireuses d'utiliser les environnements virtuels dans le milieu de travail.

En outre, la recherche pourrait mobiliser la théorie de l'ajustement entre technologie et tâche afin d'étudier la relation entre la performance individuelle et les tâches appropriées effectuées dans les VWs.

La littérature des équipes virtuelles souligne l'importance de la perspective managériale et positionne le rôle du leader dans la coordination des tâches entre les membres de l'équipe. La perspective managériale centrée sur le leadership peut être un point de départ d'une étude enrichissante de la collaboration dans les environnements virtuels 3D.

Enfin, nos résultats peuvent aider les organisations à mieux préparer leur entreprise à l'utilisation des VWs par la sensibilisation sur les défis majeurs de cette technologie émergente. En outre, les résultats de cette recherche pourraient encourager les managers à adopter ces médias et tirer profit de leurs atouts. Ils peuvent considérer notre jeu comme un pas sérieux vers la formation des gens à utiliser les environnements virtuels, il pourrait ouvrir les portes à une meilleure compréhension de ces technologies et de leurs atouts. Les listes des bonnes pratiques pourraient guider les utilisateurs à éviter les pièges éventuels et réussir la collaboration dans les environnements virtuels 3D.

MOTS CLES

Collaboration, Equipes virtuelles, Mondes virtuels, Performance collective, Jeux sérieux, Scénarios collaboratifs.

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INTRODUCTION

Modern organizations are facing several constraints such as economic forces, competitive pressures and technological advances, they created and innovated in organization and management tools in order to maintain and enhance their performance (Wang and Haggerty 2009). In this complex and non-stable context of globalization and markets' openness, evolving becomes a challenge. Thus, collaboration has become an important asset for organizations that wish to leverage collective intelligence and maximize productivity (Drucker 1989; Nunamaker et al. 1998; Nunamaker et al. 2002). According to Kock (2008), effective collaboration is one of the success key and competitive advantage of today's organization, since it allows better evolution and enhances development (Kock 2008). Indeed, collaboration is being increasingly distributed and virtual influenced by the set of technologies involved in the teamwork. According to Griffith and colleagues, technology may expand the opportunities for teams and make them more effective (Griffith et al. 2003). In addition, McGrath and Berdahl (1998) argued that technology may provide a means of structuring teamwork enhance the information available to the team, and/or provide a communication system (McGrath and Berdahl 1998).

Virtual worlds (VWs) are 3D virtual environments where users interact via avatars. They are considered as new and promising collaboration tool providing rich and interactive environments. According to Davis and colleagues (2009), VWs provide team members with new ways to manage and overcome several barriers to collaboration. In addition, these 3D environments have been found to increase group-oriented learning (Suh and Lee 2005) and process engagement (Franceschi et al. 2009). They have potential for richer and more engaging collaboration (Davis et al. 2009). Indeed, Kock (2008) considers collaboration as a key theme in organizational uses of VWs.

VWs are enrolled in a 3D trend touching the Internet, TV, serious games, etc. Following this new frame, they are becoming an adequate environment offering new forms of collaboration, new forms of social interaction (McKenna et al. 2010). Furthermore, in the business field, VWs are considered as an innovative means of team collaboration and information sharing within organizations (Chandra et al. 2009). That is, VWs provide a high potential in supporting collaborative practices in

virtual teams and constitute an additional alternative for collective work situations (Davis et al. 2009), decision making, virtual project management (Owens et al. 2009) and v-learning (Davis and Zigurs 2008).

Owens and colleagues argued that VWs are "*impacting organizational practices involving virtual teams and virtual-world project management (VWPM)"* (Owens et al. 2009) p.34. They argued that VWs could enhance collaboration and VWPM through the unique technology capabilities they provide. That is, when using VW technology capabilities, VW project teams have access to efficient, as well as richer, more engaging environments to help overcome collaboration barriers. This has motivated several companies' interest in VW technology. For example, IBM, NIKE, DELL, NASA, and BNP launched projects in Second Life, one of the best known VWs. Companies such as Schneider electric and IBM have also conducted cross-organizational collaborative projects in Second Life to combine their strengths and capitalize on a mutually beneficial partnership. Furthermore, many companies such as Cisco and IBM encourage collaboration in VWs by gathering their employees, partners, and customers on their Second Life islands (Hendaoui et al. 2008). Indeed, the aforementioned companies consider VWs as a working tool for interaction, communication, socialization, collaboration, and/or project management. Consequently, there is an increased nature of virtuality in teamwork a kind of virtual collaboration.

Vreede and colleagues (2009) interested in the collaboration practice and developed a framework describing its different components namely: people, technology, facilitation, information and process. They argued that even if collaboration practices have evolved over time from Face-to-Face setting to Screen-to-Screen and 3D virtual worlds (VWs), its main five characteristics remain the same (Vreede et al. 2009). Since these components influence each other, the introduction of a new technology to the collaboration practice would have an impact on the four other components. In this new context of VWs, the component "people" which is influenced at the individual and the team levels. In addition, facilitation may become more complex in these new environments where no eye contact either emotion exist. Besides, information level could be influenced in terms of knowledge

management and learning. In this thesis, we will try to clarify the impact of the new environment (3D VWs) on team collaboration and performance.

These VWs are defined as "*technology-created virtual environments that incorporate representations of real world elements such as human beings, landscapes and other objects*" (Kock 2008) p 1. They have evolved from being fancy chat rooms to virtual communities that support personal spaces, business (Nah et al. 2010), collaboration (Kock 2008; Nah et al. 2009) and e-learning (Chen et al. 2009; Davis and Zigurs 2008). With the emergence of such a dynamic work and play space, people can conduct these activities in real-time across the planet. Since business teams are in continuing growth, there is an increasing need to distance collaboration and work (Wang and Haggerty 2009). Further, the efficient and effective use of VWs as a platform for team collaboration may yield a variety of benefits to an organization ranging from reducing operating costs (e.g., travel, lost work time due to excessive or untimely meetings), to enhancing productivity (e.g. speed and richness of collaboration, creativity) (Wang and Haggerty 2009). In fact, a 2008 report conducted by Erica Driver and colleagues at Forrester Research, Inc. predicted that sometime between 2013 and 2015, VWs and the 3-Dimensional (3D) Internet will be as important to organizations as the Web is today. This research team also recommended that organizations begin establishing a presence in popular VWs. Undoubtedly, businesses can benefit from the marketing potential available in popular VWs, and even more so for the enhancement of essential business functions such as remote collaboration, personnel training, and the construction and sharing of 3D objects/artifacts (Driver et al. 2008a).

Recently experts have echoed the assertions of Driver and colleagues (2008), suggesting that the collaborative capabilities inherent to VWs will change the landscape of how we interact on the Web by 2015 (Gaudin 2010). Notably, that does not mean that today's collaboration technology (e.g., video conferencing, text chat, Group Support Systems (GSS)) will be obsolete; rather, pertinent technologies will be integrated into VWs (Driver et al. 2008a; Driver et al. 2008b). In many ways, the success of virtual world collaboration will be contingent on our ability to replicate real world activities in a VW such as remote collaboration. This activity is expected to yield some of the most significant business and societal implications (Bulkeley

2007; Driver et al. 2008a; Driver et al. 2008b; Kharif 2007). VWs provide the traditional advantages of online communication in that they are convenient, efficient, allow synchronous communication for team members working at a distance, and reduce travel costs. Moreover, VWs add value to the virtual collaboration process in that they offer visual, oral, and spatial dimensions to the context of electronic communication (Kahai et al. 2007; Kharif 2007).

Since the eighteenth, this notion of virtuality has often interested researchers in information systems (and more widely in management sciences) (Chudoba et al. 2005; Griffith et al. 2003; Martins et al. 2004). They studied the emergence and development of virtual organizations (teams, communities, enterprises) (Ahuja and Carley 1999; Armstrong and Hagel 1996; Boughzala 2001; Boughzala 2007; Giddens 1984; Shaw 1971). The main contributions are focusing on the opportunities that technological advances, related to information and communication, offered to companies in terms of business, collaboration, organizational learning, value creation, innovation, etc. From the early 2000s, researches have begun to explore contribution of virtual worlds as a space for social interaction and a tool to increase, facilitate and lead collaborations (Davis and Zigurs 2008). Thus, several key factors impacting collaboration are considered. They have an influence on collaboration and are related to : immersion (Guadagno et al. 2007), co-presence (Biocca et al. 2003; Slater et al. 2000), objects' creation and manipulation (Robinett and Holloway 1992), task complexity (Nah et al. 2009; Nah et al. 2011), cognitive absorption (Agarwal and Karahanna 2000), transfer of skills from the virtual world or real world and vice-versa, etc., in addition to conventional determinants of collaboration: the common goal (Johnson et al. 2002; Zigurs 2003), trust, awareness or awakening, sharing of knowledge (Cramton 2001), social loafing (George 1992; George 1995), traceability of trade (Briggs and Vreede 2005), usability of technology (Chedmaila et al. 2002), the degree of virtual teams (Martins et al. 2004), leadership (Munkvold and Zigurs 2007), etc.

3D VWs have potential for richer and more engaging collaboration (Davis et al. 2009). Further, regarding the benefits of global collaboration in VWs, there is an increasing demand by multinational corporations to implement 3D VWs in order to improve their work processes (Wasko et al. 2011).

Nevertheless, using them in professional settings is still surrounded with much hype, as their capabilities have not been yet deeply explored (Davis et al. 2009). In fact, studies in this subject should allow a clear vision with VWs lenses of this new kind of collaboration with respect of the specificities of these new media. Thus, research needs to inform and help organizations to optimally benefit from 3D VWs assets (Boughzala et al. 2012; Wasko et al. 2011). There is a need to develop theoretical understandings of the fit between collaborative tasks and VW capabilities and processes (Boughzala et al. 2012). Several researches focused in the study of this kind of collaboration; hence, they were often user-centered views. There is a lack of researches targeting the collective view of the study of this kind of collaboration and to find a manner to enhance it.

Research question

Our thesis is enrolled in this research field. The main objective is to study team collaboration in 3D virtual worlds and their impact of the use of such collaboration tools on team performance. Several research teams have embarked on the study of collaboration in virtual worlds (Davis et al. 2009),we could cite (Bergin et al. 2010; Cahalane et al. 2010; Chandra et al. 2012; Davis et al. 2009; Goh and Yoon 2010; Goh and Wasko 2010; Hassell et al. 2009; Hendaoui et al. 2008; McKenna et al. 2010; Meyer and Swatman 2009; Venkatesh and Windeler 2012).However; very few of these researches have tried to assess the impact of the use of virtual worlds in workspace on collaboration and team performance. Existent researchers studied specific factors influencing collaboration using qualitative and quantitative approaches. However, several important determinants have not been studied in depth in the context of collaboration in 3D virtual worlds. Indeed, the use of these technologies in workplace is still surrounded with much hype there is a need to provide concrete responses to companies wishing to use this kind of technology about the impact on performance and best practices of their use.

In this research, we are trying to respond to the following question:

How can we use virtual worlds to enhance team performance?

This research question could be detailed in four sub-questions as follow:

- **Which are determinants of collaboration in 3D virtual worlds?**
- **Are there any differences between 3D virtual worlds and other media to support collaborative activities ?**
- **What is impact of the specific characteristics of 3D virtual worlds on the individual and the collective performance?**
- **How could we enhance collaboration in 3D virtual worlds ?**

Tasks of the research

This research tries to respond to a research gap and a business need. Indeed, we are trying to fill into the gap of identifying, categorizing and studying relevant determinants characterizing team collaboration in 3D virtual worlds in the aim to understand the impact on performance and enhance it. In addition, we are trying to meet a business need of companies about the use of virtual worlds in workplace by providing a set of best practices.

Hence, the objectives to meet the research gap are the following:

- Identify salient constructs that characterize collaboration in 3D virtual environments that have not been studied in depth.
- Categorize them into three categories namely technology, individual and collective. In the aim to get more complete landscape of determinants.
- Study the impact of using these environments on team performance.

⇨ Establishing research models allowing a better understanding of the impact of virtual environments on team performance in collaboration.

The objectives to meet the business need are the following:

- Understand how to collaborate in a better manner in these virtual environments taking into account determinants identified in the literature and through exploratory study.
- Discover best practices to use 3D virtual environments in workspaces.

⇨ Design collaborative scenarios (Serious Game) allowing users to understand collaboration in 3D virtual environments.

Methodological Framework

Starting from a rich background of theories from the literature, this study has presented a variety of them in the aim to understand the importance of technology capacities and social interactions in teamwork. Social presence theory, Media richness theory, Media synchronicity theory and Task-technology fit theory have been found useful to this research from a behavioral science side. In addition, the theory of Experiential Learning, the Social Cognitive Theory and the Self-determination theory were relevant to integrate a learning-by-doing experience when designing collaborative scenarios.

From a methodological point of view, this thesis is based on the Hevner's and colleagues (2004) IS research framework combining behavioral science and design science. We designed a methodological framework aiming at bring a method to meet both the business need and the research gap. This framework contains several iterations between behavioral science and design science.

Indeed, from the behavioral science side, research models characterizing collaboration in 3D VWs were established. Then, exploratory and empirical studies were conducted mixing between qualitative and quantitative methods. From the design science, based on determinants of the research models, a set of collaborative scenarios was designed aiming at facilitating the study of collaboration in 3D VWs. They allow the variation of collaborative situations and could be used as training for new VWs users.

As these two paradigms are complementary, design science scenarios will integrate behavioral science results (determinants). Behavioral science models will be enhanced by the insights extracted from these collaborative scenarios.

Finally, this framework highlighted two kinds of contributions expected from this research: A theoretical contribution providing research models characterizing team collaboration in 3D virtual worlds and a practical contribution providing a set of collaborative scenarios.

Indeed, this framework describes a longitudinal study of team collaboration in 3D VWs. In this thesis, we present a first iteration of this framework with two research models and two kinds of collaborative scenarios (Project manager and teammates).

Results

In this research, we have achieved the objectives mentioned above with several relevant results. The literature review and the first exploratory study were bringing a full landscape of VWs and their importance as an alternative to face-to-face setting. Determinants have been identified and studied in quantitative studies. These studies brought deep understanding about the dynamics of the impact of the use of VWs in workplace. They argued that the selected determinants was influencing team collaboration and measured their impacts on team performance. This study highlights the impact of the technology assets and the extent to which users are at ease with it. The example of customization and object manipulation were witnessing this impact by their influence on knowledge sharing. Besides, the importance of human attitude has also a determinant effect to make the collaboration successful. For instance, full interaction between teammates could make the communication fuzzy and complicated in the same time the presence of loafers within the team will make the productivity on drop. In addition, the smooth knowledge sharing and the ability to apply this shared knowledge are impacting the collaboration process on the individual and the collective level. Finally, successful collaboration is possible in VWs with the respect of a set of best practices.

Literature review

Chapter I

This chapter presents a literature review about virtual worlds and serious games and their use for serious purposes.

Chapter II

This chapter studies the use of virtual worlds in team collaboration.

Methodological framework and theories

Chapter III

This chapter presents a literature review about théories influencing this study and their importance to our study.

Chapter IV

This chapter presents our methodological framework and explains the importance of each study.

Case studies and experiments

Chapter V

This chapter presents our qualitative exploratory study.

Chapter VI

This chapter studies the impact of the use of 3D virtual worlds (Second life) on team performance by comparing them to the traditional contrepart (Skype).

Chapter VII

This study related about a field study with professional using virtual worlds in their workplace.

Chapter VIII

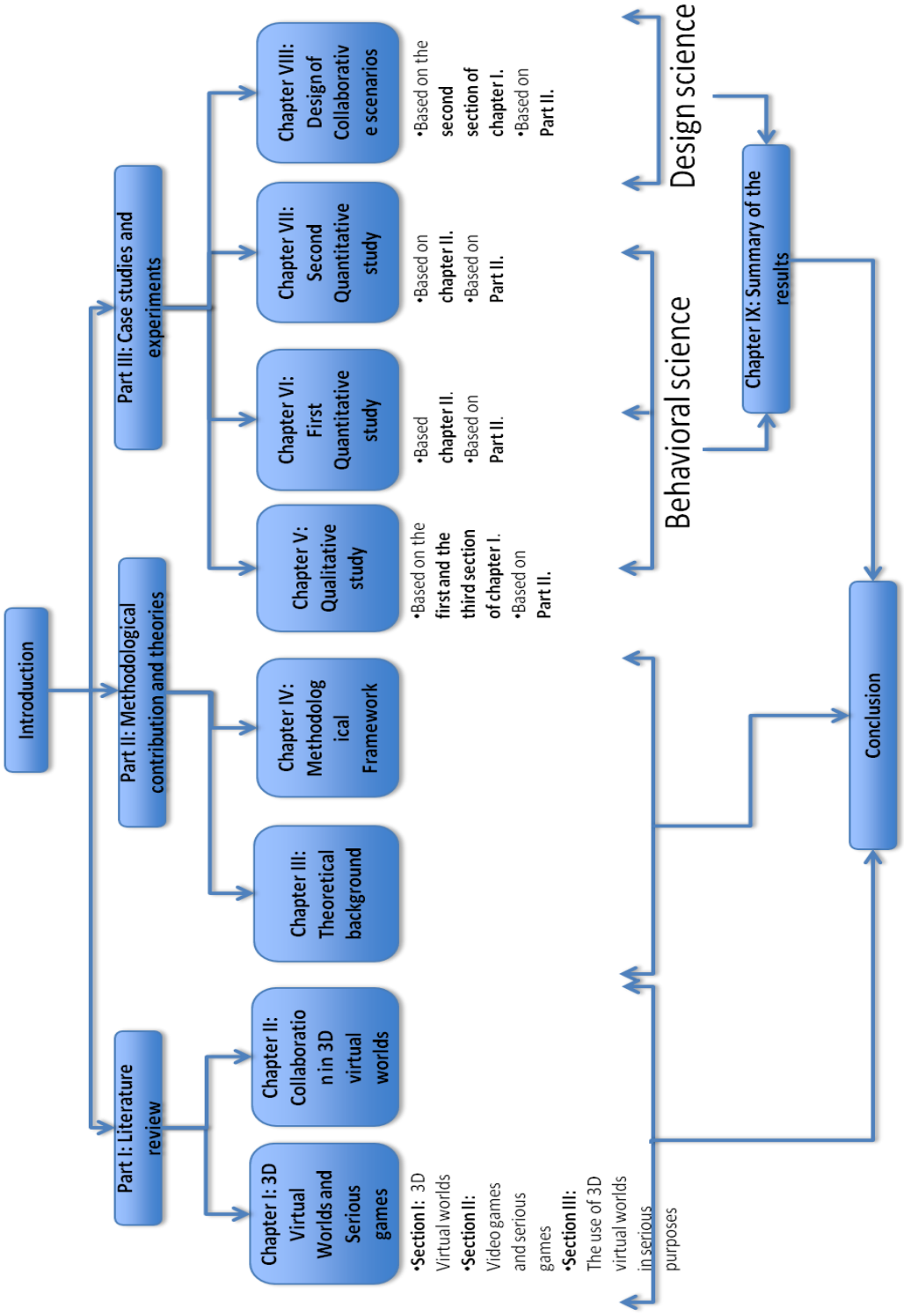
This chapter presents the design and the evaluation process of a new serious games presenting a set of collaborative scenarios targeting teammates and project manager.

Chapter IX

This chapter presents the summary of the results brought by differents studies.

The following figure describes the plan of this dissertation.

Reminder of the document



LITERATURE REVIEW

INTRODUCTION TO THE LITERATURE REVIEW

This literature review explores 3D virtual worlds and serious games. It aims at providing deep presentation of these new media and focuses on their use in workspace. Consequently, we are concerned about identifying key papers about 3D virtual worlds and their use for serious purposes more particularly about collaboration in 3D virtual worlds. In the same time, we are interested in serious games and especially collaborative ones.

Type of the literature review

There are four types of literature review (Okoli and Schabram 2010; Webster and Watson 2002) namely Domain oriented, narrative, meta-analysis and systematic review.

- **Narrative:** this type of literature review tries to bring a sequential presentation of along many topics or concepts and link them to the goal of the study.
- **Domain oriented:** it is generally narrative but it focuses on narrow range of knowledge and domain oriented research questions
- **Meta-analysis:** this type is based on a quantitative process that analyzes a collection of studies in the aim to integrate the findings.
- **Systematic review:** inspired from medical research, this literature review is supported by a set of rigorous guidelines allowing more precision on the definition of research question and the full documentation.

The approach we used to elaborate this state of the art is called domain oriented. Hence we used a narrative reviews and we lead the reader progressively to our focus and gap. We have focused more in a narrow range of knowledge specific to virtual worlds and serious games.

Process of the literature review

The process of literature review started by the beginning of this thesis in November 2010 until September 2011. Our literature review was focused on best resources from

the literature (conferences and journals cf. table 1), we have mentioned here only resources that published articles in the scope of this research.

The literature review was incremental regarding new published papers in the domain.

- **Searching:** We used a set of key words in our research in the literature such as virtual worlds, collaboration in virtual worlds, serious games, collaborative serious games, etc.
- **Filtering:** We started by collecting abstracts of papers focusing our areas of concern.
- **Selecting:** We classified them to eliminate those that are out of the scope of our research and organize a reading list of papers.

Resources of the literature review

We used many research engines and databases such as Google scholar, Science direct, IEEE explore, Business Source Complete, Springer, Jstor, etc.

Most of our references have been carefully chosen from best-known journals and conferences in information systems, computer sciences, sociology, psychology, etc. We provide a list of major recourses (conferences and reviews) we used in our research:

	Name of the conference
AMCIS	AMericas Conference on Information Systems
CSCW	Computer-Supported Cooperative Work
ECSCW	European Computer-Supported Cooperative Work
ECIS	European Conference on Information Systems
ICIS	International Conference on Information Systems
HICSS	Hawaii International Conference on System Sciences
PACIS	Pacific Asia Conference on Information Systems
	Name of the journal
JAIS	Journal of the Association for Information Systems
MISQ	Management of Information Systems Quarterly
DSS	Decision Support System
ISR	Information System Research

Table 1 Most important resources used in the literature review

CHAPTER I: 3D VIRTUAL WORLDS AND SERIOUS GAMES

1 Introduction of chapter I

This chapter contains three main sections namely 3D virtual worlds, video games and serious games and the use of virtual worlds in serious purposes.

The first section gives an in depth literature review about fifteen best-known 3D virtual worlds, their importance, the set of areas touched by this technology. This chapter classifies them through a set for criteria namely user, environment, avatar and business model. It shows the importance of the graphical design. The strength of the community and the number of active subscribers has been found to determine the success of a virtual world. We discovered also that virtual worlds are diversified and targeted large panoply of users from different ages. We highlighted also the interactivity of these environments by studying the means of communications. Finally, the study focused on the fields of use of these virtual environments which have been found to touch social networking, gaming, collaboration, learning, tourism, etc.

The second section, we provided an in depth literature review about video games and serious games. We explained the different between a virtual world and a serious game. This section explains the importance of serious games in education and in workspace. The main characteristics of these games have been also studied. As we are focusing in collaboration, we have explored collaborative serious games.

The third section studies the implication of the use of virtual worlds in several fields namely virtual project management, facilitation, immersive v-learning and social skills and leadership. This literature review gives us an overview about the importance of virtual worlds and highlights a set of their advantages. The resulting literature brings new insights about factors encouraging the use of virtual worlds and other discouraging it.

SECTION I: 3D VIRTUAL WORLDS

"Virtual Worlds are the next wave in human communication technology allowing us to work and play together while being geographically distant."
Brian A. White[3]

2 Introduction

The perpetual evolution of technology is making organizations in competition to follow it. As technologies are becoming present in all fields, the study of their assets and their use is crucial to better take advantage of them. Virtual worlds are promising technologies providing many profitable opportunities for organizations appear and have been used in workspace. This innovation has captured the attention of several researchers, some studied the acceptance of these new worlds, other studied the influence of their use as a collaboration tool, others studied the business and educational side, some researchers studied social interaction in the community of gamers and their behavior, etc. Indeed, virtual worlds are very diversified providing many fields of application. Therefore, in the aim to deepen the understanding of virtual worlds specificities, we present in this section a literature review to highlight more closely their main features and taxonomy of their key types.

3 3D virtual worlds

3D VWs are three-dimensional computer-generated environments (Bartle 2003; Boughzala et al. 2012; Davis et al. 2009; Messinger et al. 2009) having their ancestors on video games (Messinger et al. 2009). They are commonly known as game-based environments and human beings interacting inside them are called players. 3D virtual worlds' users interact with each other through their "avatars" – the "incarnation" or the graphical representation of the users inside the 3D environments (Bessière et al. 2006; Li et al. 2010). Avatars are under the control of users in terms of appearance and behavior (Boughzala et al. 2012) and they are the means by which people chat, speak, touch, fly, and teleport (Messinger et al. 2009). Indeed, these environments provide people the possibility to communicate through text messages or voice over headset and microphone, to drive vehicles and fly in the sky, to customize the shapes of their avatars, to build and set their own virtual objects, etc. Users can touch objects

3 The author of White, B. A. 2007. *Second life: A guide to your Virtual World*, (1st ed.) Que.

and manipulate them; they can also have some facial expressions and cues such as moving hands, smiling laughing, and shaking hands (Davis et al. 2009; Venkatesh and Windeler 2012). They constitute a shared social environment, real-time interaction between users, graphical customizable interface, user-generated content persistence, and active support for in-world social groups (Franceschi et al. 2009).

3D VWs are a metaphor of real life where you can find houses, cars, stores, gardens, universities, beaches, etc. Users could surf inside them using the arrow keys of their keyboards or their mice; they can teleport themselves to a virtual address by a simple click. These environments are entertaining and providing an escaping place to the user to experience a new life. They could be affected by several persons simultaneously and they continue to function even if no one is using them (persistent) (Bartle 2003). According to Bartle (2003), they evolved from text-based environments called text MUDs to more developed environments called graphical MUDs with the introduction of computer graphics (MUD originally Multi-User Dungeon, with later variants Multi-User Dimension and Multi-User Domain).

Like most (Multi-User Virtual Environment) MUVE, VWs users customize their avatars, and can exhibit just about any real-world behavior, such as making friends, interacting socially, shopping, vacationing, and doing business. Users can create and manipulate objects/artifacts in their environment ranging from images and tools, to their own island paradise.

Several means of communication exist in these environments and can be categorized into two main types namely non-verbal and verbal. In the majority of virtual worlds, avatars are able to imitate some non-verbal cues such as somebody's gestures and postures (e.g. moving hands and heads, having some facial expression, etc). These developed features made users feeling as if they are experiencing a new virtual life with high level of realism. Besides, avatars are capable to communicate through text message (chat), private messages, and group messages or to have a voice conversation. Pereira (2010) provided a taxonomy of communication modes between avatars in virtual worlds (Pereira 2010).

	Non-verbal	Verbal
Communication modes	• Avatar posturing • Avatar appearance • Movement • Non-verbal • Sound effects	• Text-chat • Private instant messages • Group instant messages • Voice-chat.

Table 2 Taxonomy of communication modes between avatars in virtual worlds

Virtual worlds are very diversified in terms of goals and targeted community, Messinger and colleagues (2009) classified them into five prominent classes:

- **Education-focused:** This category provides training in architecture and design, procedural skill development or constitutes a language learning laboratory, etc. They require a set of fundamental technical preconditions mainly sophisticated avatar communication tools and high performance materials for learning such as the virtual world Activeworlds[4].
- **Theme-based:** This category is gathering virtual worlds promoting a particular content among a community. They aim at fostering member's access and socialization around themed topic of the community such as vSide[5].
- **Community-specific:** This category targets membership from a particular region or country adopting the national language for their interface and primary communication language of their members such as HiPiHi[6].
- **Children-focused:** This category targets children. These virtual worlds are focusing mainly on education, or socialization or fantasy gaming. They are adopting slightly different models from those targeting adults such as Neopets[7].
- **Self-determined:** They are also called open-objective. These virtual worlds present several motivations mainly socialization and business. They are

[4] https://www.activeworlds.com/
[5] https://www.vside.com/app/start
[6] www.hipihi.com
[7] http://www.neopets.com/

open-purpose virtual worlds allowing users to be more creative. They target a very diversified population such as Second Life.

The company Kzero gives another classification which is more specific and precise comparing to the one provided by Messinger and colleagues (2009). Indeed, Kzero[18] categorizes virtual worlds into twelve types:

- **Socializing / Open:** These environments are mainly focusing on social networking like chat or user interaction more than gaming such as Kaneva[9].
- **Casual Gaming:** These environments are gaming malls such as Neopets[10].
- **Misc:** These environments are faith-based worlds such as Bible islands[11].
- **Mirror:** These worlds are simulating places in the real world such as Twinity[12].
- **Questing / Adventure:** These worlds are game-based environments including fantasy roleplay and focusing on exploration and questing such as World of Warcraft[13].
- **Toys / Real World Games:** These worlds are based on existing games and toys such as Barbie girls[14].
- **Music:** These worlds are focusing on music such as Planet Cazmo[15].
- **Fashion / Lifestyle:** These environments are focusing on avatar customization and dressing-up such as Stardoll[16].
- **Education / Development:** These worlds are focusing on self-development and learning such as Ecobuddies[17].
- **Sports:** These worlds are focusing on sports such as Planet soccer live[18].

8 http://www.kzero.co.uk/. Kzero is a worldwide consulting company positioned at the heart of the rapidly growing and wildly exciting sectors of virtual worlds, virtual goods and augmented reality. http://www.kzero.co.uk/blog/state-virtual-worlds-market-kzero-radar-chart-q1-2013/
9 www.kaneva.com/
10 http://www.neopets.com/
11 http://www.bibleislands.com/
12 http://www.twinity.com/
13 http://us.battle.net/wow/en/
14 games.barbiegirls.com/virtualworld/en/
15 http://www.planetcazmo.com/
16 http://www.stardoll.com/fr/
17 http://www.primarygames.com/arcade/virtualworlds/ecobuddies/
18 http://www.planetsoccerlive.com/

- **TV / film / books:** These worlds are based on existing books, films and TV channels such as Petra's planet[19].
- **Content Creation / UGC:** These worlds permit their users to create new objects and assets such as Second Life[20] (more details about Second life are provided in appendix 3).

Virtual worlds are present in a variety of areas including but not limited to:

- Education (simulations and serious games to contribute to active learning).
- Entertainment (video games such as MMOG[21]s. More details about MMOG are given in appendix 4)
- Socialization (e.g. romantic encounters).
- Business / Work (e.g. collaboration, trading, advertising, etc.).
- Architecture (e.g. model testing with users).
- Environment (e.g. humanitarian and sustainable development).
- Military. (e.g. combat training or managing difficult situations in wars).
- Medical. (e.g. providing a testing environment for hospitalized children with serious illnesses, or autistic).
- Etc.

After this general presentation, we find it worthy to deepen the understanding of their potential by the study of 15 best-known virtual worlds. This study will highlight the importance of virtual worlds' assets and design and the set of communication means provided to users. We will understand the specificities of each virtual world regarding the business model and the targeted community.

4 An overview of 15 best-known virtual worlds

According to Kzero the number of Virtual worlds is increasingly growing (more than 800 VW) with more than 9 billion dollars of revenues in 2013 (Appendix 1).

[19] http://www.petrasplanet.com/site/
[20] https://secondlife.com/
21 Massively Multiplayer Online Games

Every virtual world has a set of criteria that differentiate it from others and allow it to target a certain audience. Usually these worlds are open access with several types of accounts (public, premium, etc.). The access to these environments could be done by simple web site or peer-to-peer with a downloadable version to be executed on the clients' devices. However, these environments require higher graphical capacities and a good Internet connection. Some virtual environments seem to be similar but they don't have the same success among virtual worlds' users. To understand the differences between them, we used a list of criteria to classify them. We have structured the criteria into different categories such as the user, the environment, the avatar use and the business model. The number of virtual world is exceeding 800 (cf. Appendix 1), so we will focus on 15 best-known virtual worlds from different types more information are given in appendix 2.

Users

It is important to study the users of each environment in the aim to understand the category of people targeted and their interests and needs. Actually, the popularity of a virtual world is crucial to its success

Virtual worlds targeting teenagers (such as WeeWorld, Neopets and Habbo) and gamers (such as WoW) are very popular and gathering more than 20 millions of users. Second life and IMVU also have strong communities (more than 20 millions of users). The strength of community is determinant to the spreading and the success of the virtual world. In Appendix 2, table 27 provides more details about the community of each virtual world.

Environment

The environments features are important to attract users. Usually the playful aspect of these worlds and the high design quality make them appreciated. Mainly, we have focused on three aspects namely environment degree of customization, the degree of ease and fun to access and the means of communication provided by the environment. We found relevant to focus on the environment customization because it is a means by which users could be more at ease with the environment (Suh et al 2011). Customizing the environment is a kind of appropriation of the virtual world. Some worlds promote the user imagination and creativity by allowing him/her to create and

add new objects. Besides, the place of the virtual environment and its reputation could enable the access to community of interest and make users in touch with new professional networks or new friends. In addition, the degree of ease and fun to access objects could be an enabler to the user attachment to the environment.

Several virtual worlds, mainly those with gaming and adventure nature, are not allowing environment customization such as LOL[22] or Kaneva. The majority of presented virtual worlds provide at least real time interaction between avatars via chat.

Usually they provide acceptable level of ease of use of virtual objects. This feature is being very sophisticated in gaming category of VWs because players need higher level of interaction with virtual objects in the game. While this feature is not very developed in VWs targeting enterprises such as Active worlds.

In Appendix 2, table 28 provides more details about the different environments of each virtual world.

Avatar

The avatar is the embodiment/graphical representation of a user in the virtual environment. We have focused mainly on the ease to manipulate the avatar and to surf in the environment, the degree of customization of the avatar and the ease of object manipulation. In this part of the literature review, we realized that the avatar is a fundamental element of the virtual world since it could be similar to user shape. The avatar could be proposed by the environment and the user has to choose between a set of proposed models. User can create new clothes, faces, hairs, eyes, etc. and change the appearance of his/her avatar. The majority of the presented VWs are providing an ease of avatar manipulation and customization.

Higher degree of object manipulation makes the user more at ease in the environment and feeling as if they are in the real world.

In Appendix 2, table 29 provides more details about the use of avatars in each virtual world.

[22] League of Legends

Business Model

The business model plays an important role in the use of a virtual world. Several companies prefer to provide open access to public profiles with restricted capabilities and provide advanced features to paying profiles. For example, in Second life, users must buy a land to have a persistent building with an address. However, public profiles could have access to open sandboxes and build temporary objects that will be removed automatically later (by the owner of the sandbox). Free profiles are allowed to make the virtual world accessible to many more people and thus guarantee a certain use of the environment. Payment modes are slightly different; usually people buy virtual money (Linden dollars for Second Life, the global for Twinity, Vbux for vSide, etc.) with their credit cards or paypal account. They can earn money by participating in events or wining quests.

Several virtual worlds such as sMeet and Twinity provide add-ons with different fees while LoL have no add-ons. These modules are usually objects such as clothes, decors, weapons, etc. which will be exchanged with a certain amount of local virtual money. In Appendix 2, table 30 provides more details about the targeted activities in each virtual world.

In the aim to deepen the understanding of VWs assets, we provided more details about Second life (Appendix 3) and World of Warcraft (Appendix 4). They are two best-known and most influencing virtual worlds (Davis et al. 2009) in terms of number of users, the strength of the community and the amount of research done about them.

5 Conclusion

Virtual worlds have found to be very diversified and rich. Depending on the targeted community, several features related to their design are changing mainly the avatar and the environment. In the next section, we will present the ancestors of virtual worlds: video games. Our focus will be especially on serious games which will be relevant for our design science part.

SECTION II: VIDEO GAMES AND SERIOUS GAMES

"In gaming culture, games are not just played, they are talked about, read about, 'cheated', fantasized about, altered, and become models for everyday life and for the formation of subjectivity and inter-subjectivity. There is a politics, an economy, a history, social structure and function, and an everyday, lived experience of a game."
Suzanne De Castell and Jennifer Jenson[23]

6 Introduction

It has been a long time since video games appeared in the forties; they were used as research objects to study and illustrate the human-computer interaction. Video games are considered as the ancestors of virtual worlds (Messinger et al. 2009). Both of them could be used for serious purposes such as learning. In the context of this thesis, we are focusing on collaboration skills, so we will try to highlight not only the support of serious objectives by serious games, but also the collaborative games. In this section, we will the difference between virtual worlds and video games; we will study the characteristics of video games, serious games and collaborative serious games.

7 Video games Vs. Virtual worlds

Video games are digital games or computer games (Kirriemuir and McFarlane 2004) designed basing on a set of goals mainly entertainment. When a simulation is needed, virtual world will not suffice (Ulicsak 2010). A virtual world offers an environment, a context and a set of tools (Davis et al 2009) but it will not guarantee sophisticated scenarios (Franceschi et al. 2008) for an educational simulation for example. For instance, in World of Warcraft, players may learn deep, transferable, even measurable leadership skills but not of them will (Goh and Wasko 2010). Indeed, it hasn't a pedagogy or a structure ensuring learning skills (Ulicsak, 2010). Hence, we can't generalize that all players will learn the same skills and we can't

[23] Two of the founders of Canadian Game Studies association
De Castell, Suzanne and Jennifer Jenson. "Serious Play", Journal of Curriculum Studies, 35/6 (2003). http://faculty.ed.uiuc.edu/westbury/jcs/Vol35/decastell.html

adopt them in a leadership development program. Second life could not be considered as a game, it lacks many characteristics of a game mainly goals, rules, game play, scoring, etc.

8 Video Games

Since 1946, with the Whirlwind project at MIT[24], people witnessed the introduction of the first simulation that allows pilots of military aircraft to train in controlled environment. Then, learning takes place by trial and error where the state of flow and the immersion are strengthened. Pong game was the first success in public in 1972. Later, after the democratization of video games, the use of simulators became popular, such as "Flight Simulator" which appeared in 1982.

Video games are very popular among young generation (Assmann et al. 2010) thanks to their attractive assets such as graphics and sounds. Prensky (2001, p106) provided an exhaustive list of attributes characterizing games:

- “Games are a form of fun”
- “Games have win states. That gives us ego gratification”
- “Games are a form of play”
- “Games have a representation and story”
- “Games have goals”
- “Games are interactive”
- “Games have outcomes and feedback”
- “Games are adaptive”
- “Games have conflict/competition/challenge/ opposition”
- “Games have problem solving”

These characteristics make video games, especially serious games, to be a dynamic platform for active learning when the content presented by the game has a purpose (Ulicsak, 2010). In the next part, we will be interested in serious games.

[24] Massachusetts Institute of Technology

9 Serious games

The term serious game is an oxymoron invented around for over 45 years by Clark Abt (Abt 1970). The vocation of this kind of games is to prompt the user to interact with a computer application that aims to combine aspects of teaching, learning, training, communication or information, with play jurisdictions and / or technologies from the video game. This association aims to provide a content utility (serious) approach videogame (game). It is achieved by linking a scenario utility with a playful scenario.

Serious games could be defined as video games (Egenfeldt-Nielson et al. 2008; Felicia 2009; Kebritchi et al. 2010; Sawyer and Smith 2008) “with a purpose” or serious objectives (Stone 2008), designed for trainings and educational purposes (Felicia 2009; Kebritchi 2010) so they move beyond entertainment (Stone 2008) per se to deliver engaging interactive media to support learning in its broadest sense.” (Stone 2008).

Alvarez (2007) defines them as "computer applications having as original intention to combine both serious aspects (serious) (Alvarez and Rampnoux 2007), with fun aspects from video games (game). Such an association is achieved by providing a learning scenario corresponding, from a programming point of view, to implement a decor (sound and graphics), story and suitable rules; therefore it moves away from restricting the game to entertainment ". Indeed, SGs are entertaining games for educational purpose. The main objective is to exploit the entertaining aspect of video games to facilitate learning concepts much more serious which are traditionally taught through conventional teaching or training methods. The range of usage areas of SGs is very wide such as scientific exploration, medicine or education. More precisely the educational aspect of SGs is one of their greatest assets. Indeed, they are promoting and opening new horizons for active learning. They are interactive and well accepted thanks to their graphics and design. As they are transferring a serious content, they have to be pedagogic and engaging (Alvarez and Rampnoux 2007).

Serious games are real trainings aiming at a target far broader than the common games (Alvarez and Rampnoux 2007). Thanks to their interactivity and pedagogy, serious games provide a “learning by doing” experience to players rather than

listening or reading. To achieve such serious objectives, serious games need to be engaging and following a pedagogy (Ulicsak 2010) and targeting a set of pedagogical objectives.

Serious games are enrolled in the environments for human learning (EHL) by combining machine-mediated learning, simulation, use of emotions and professionalism. Regarding the relevance of such games, CSCW 2010 and CSCW 2012 have set two workshops about serious gaming in workspace. In addition, universities are integrating them into the classroom and educational process such as the University of North Carolina Greensboro. Teachers have developed a hands-on video game design workshop used for an MBA course on design thinking. They consider this approach as a novel approach to teach complex concepts and skills to business students.

Thanks to their approach mixing seriousness and fun, motivation and perceived ability of individuals to process complex information or to repeat behaviors have been improved. Indeed, companies have moved to games for continuing education in order to promote behavioral and inter-relational dimensions, for technical skills (management, decision support, etc.) but also for general skills.

Several organizations are experimenting and integrating the use of synthetic worlds like serious games and virtual worlds in their daily use, thanks to their opportunities. Specifically, serious games are becoming very common in companies such as BNP Paribas, IBM, and Michelin, etc. They are developed for advertisement, recruitment, trainings, etc. (Lang et al. 2009). According to Boudier and Dambach (2010), their company has reported real "mutation" among customers' requirements on training products (Boudier and Dambach 2010). The new corporate trend is to produce and use serious games. They are well accepted by employees increasingly trained in IT and who consider these trainings as more modern and fun.

The increasing use of Information and Communication Technologies (ICT), and their continually rising complexity, offers a new horizon for training opportunities and tools. However, these technologies require that teaching methods would be adapted to the new generation of students (digital natives[25]) who increasingly use

[25] A digitla native is a person who is using digital technology since his/her early age.

diverse and sophisticated tools. Considering the transformation of pedagogy related to technological evolution and the momentum of active teaching, using SG in higher education, is enrolled in the desire to anticipate in order to be in line with the new teaching methods already used in colleges and high schools. In addition, using these advanced tools will prepare individuals to be familiar with them for the professional context. A SG is, indeed, using the same design approaches and expertise as a classic video game, but its playful approach goes beyond the single dimension of entertainment. It's considered to as a real tool for awareness, training or promotion. It is a "useful" kind of video games put in service of professionals. Some SGs are emerging and established as real means of communication: a modern medium, flexible and easy to access with the presence of the Internet and the explosion of interactive entertainment.

Actually, according to (Gee 2008; Prensky 2001), the pleasure and the richness of experiences in the game will increase the learner interest. Thus, SGs sublimate learning by providing a solution to the ultimate problem which is to make a learner interested in a subject that didn't interest him/her from the beginning. Several studies have been conducted on SGs in the education area. Thus, according to Rooney (2007) one of SGs' challenges is to find the right synergy between pedagogy and learner engagement (Rooney and Namee 2007). Indeed, strongly favoring pedagogy at the expense of engagement risks to make to learner loose the interest in the game. Conversely, favoring engagement at the expense of pedagogy risks to make SGs lose their original utility. Further researches on SGs and young children were also conducted. For example, Peterson (2008) shows that SGs help children acquire skills and abilities such as: strategy, problem solving, logic, psychomotor coordination, concentration, motivation, organization, memory, creativity, exploration, communication, group work and decision-making (Peterson et al. 2008). In the same paper, the author emphasizes that research should be conducted before being able to apply the principles of theoretical education in games.

Furthermore, they have a high level of fidelity of graphics that gives them close resemblance to actual events (Stone, 2008). Consequently, imagining learning situation and collaboration scenarios could be feasible in this kind of games.

We provide in appendix 4 and 5 different types of serious games and their characterization and evaluation. In this research, we are more concerned about collaboration; in the next part we will provide a literature review about collaborative serious games.

10 Collaborative serious games

In his book about collaboration engineering, Boughzala (2007) distinguished between the notions of cooperative work and collaborative work. The first is when individuals work together and share a common goal (group cooperation). Involved people are committed volunteers (without hierarchical pressure) for achieving the action. A co-operative game is then a game where groups of players ("coalitions") may enforce cooperative behavior; hence, the game is a competition between coalitions of players, rather than between individual players. They would win together or lose together. The second notion describes a situation where individuals work together with others without engaging in the group and share a common goal (individual cooperation). A collaborative game is a game when players work together to achieve the game goal (Boughzala 2007).

Several serious games are encouraging collaboration between players to achieve the game's goal. Collaboration is not the main aim of the game but a manner to synergize efforts. It could exist in serious games when all players are fighting against a common enemy (e.g. America's army) or when players want to exchange useful information and experience (e.g. the Power of research). In Massively Multiplayer Online Role-Playing Game (MMORPG) such as War of Warcraft (WOW), players must form teams and successfully coordinate to defeat enemies in extremely difficult dungeons. The principle of a MMORPG is to encourage collaboration because the challenge given in the game is almost impossible to be done by one person.

These games involved a collaborative dimension without having collaboration as the learning outcome of the game.

Two studies have targeted games teaching collaboration. Toups and colleagues (2009; 2011 a, b) and Song and Kleinman (1994). The first research targeted an instrument that teaches team coordination in firefighting context (Song and Kleinman 1994). This game is not a 3D serious game, but a game focusing only team

coordination skills. While the second research is targeting a DDD (distributed, dynamic, decision-making) simulator for team decision-making experiments and job scheduling (Toups et al. 2009; Toups et al. 2011a; Toups et al. 2011b). However, this game is not a 3D serious game, but a simulator developed on UNIX environment.

11 Conclusion

In this section, we highlight a business a need of a collaborative serious game allowing its players to experience collaborative scenarios and to learn more about how to collaborate in a better manner in a 3D virtual environment. This business need will be the main subject of our design science part in chapter VIII.

As video games and virtual worlds could be used to achieve serious objectives, in this section, we have seen together that video games become serious games when they focus on serious goals. In the next section, we will present the use of VWs in some serious purposes.

SECTION III: THE USE OF 3D VIRTUAL WORLDS FOR SERIOUS PURPOSES

"If we were meeting in Second life or in World of Warcraft to chat, we would both have the sense of being in the same place overlaid on our sense of physical location, the experience encodes into our memories as if we ever in the same place."

Daniel laughlin[26]

12 Introduction

3D VWs such as Second Life are becoming important tools supporting many activities like socialization, social networking, entertainment, collaboration, business development (Mennecke et al. 2008; Pike and Murphy 2009), V-learning (Davis and Zigurs 2008), virtual project management (Owens et al. 2009), facilitation (Franceschi et al. 2008), etc. many of these activities are related to the collaboration activity such as virtual project management, v-learning and facilitation. The understanding of these activities could help us to enrich the understanding of the main purpose of this thesis. In this section, we provide a literature review of the use of virtual worlds in many fields.

13 Serious purposes and 3D virtual worlds

VWs provide IS researchers a unique opportunity to study their creation and their management, their use and misuse and, finally, their influence and impacts on users, communities, organizations and -more widely- their impact on societies (Mennecke et al. 2008) and on business (Zhao et al. 2010). They provide a unique experience to individuals and allow them to interact with other avatars (Eschenbrenner et al. 2008) and with objects in these environments; they allow them to do many things that didn't exist necessarily in our real world (Eschenbrenner et al. 2008).

Virtual Project Management

[26] Learning technologies project manager at NASA Goddard Space Flight Center.

With the expansion of modern firms, physical meeting are not feasible to be done with all members who could be geographically distant (Hassell and Limayem 2010). In fact, managing modern organization is a crucial task that requires innovative measures and tools which are intended to facilitate the interaction in teams (Damart et al. 2010).Virtual Project Management (VPM) becomes a crucial task for organizations and manager of virtual teams. VPM is directly related to a collaborative context, so its study could help us to widen our understanding about collaboration in VWs. Owens and colleagues (2009) define virtual worlds projects as "*those conducted partially or wholly in a VW through a collaborative team of avatars and people*" (Owens et al. 2009) p.34.

Facilitation

Facilitation is considered as one of the collaborative practice's components (Vreede et al. 2009). It occurs in a collaborative context between a facilitator and the rest of team members, it aims at enhancing team management. However, facilitators are confronting several troubles because of the lack of face-to-face communication. In general, collaboration technology are accepted by facilitators and their use could optimize facilitation techniques (Dickson et al. 1996; Franceschi et al. 2008). Although with the introduction of 3D VWs, interpersonal and leadership dynamics in team collaboration are different than the real world (Wigert et al. 2012).

The facilitator could be confronted to more challenges related to the new collaboration context. Facilitators could lack of understanding about participants' feelings and reactions such as misunderstanding as there is a lack of body language comparing to a face-to-face setting. Moreover, charisma changes in VWs because in real world gestures, expressions, voice and movements are much easier. Furthermore, miscommunication could occur between team members. Therefore, facilitators should be able to resolve conflicts and team members' problems.

Virtual learning

Electronic learning appeared a useful tool to address applications in distance education after the Internet vulgarization. It does not allow direct exchange between the learner and the teacher which may lead to loss of motivation of the student.

Learning is following the development of technology. Actually, it is impacted by the introduction of 3D virtual worlds in the educational arena. V-learning is based on a radically different interface than the existing conventional e-learning web sites. Indeed, the user is no longer confronted to a typical website interface that even well done, is relatively smooth and cold. 3D virtual worlds provide a model based on self-projection in a 3D environment through an avatar. The purpose of such technology is the feeling of immersion and the reduction of the distance between learners and teachers.

Leadership and social skills

Leadership and many other social communication competencies/skills could be learnt through video games or any rich media such as virtual worlds (Ducheneaut et al. 2007). The main purpose of MMO gaming is to evolve from one stage to another by acquiring desirable loot which will make the player more powerful. To do this, players should increase their collaboration and interdependence especially when different characters could complement each other's strengths and weaknesses in the aim to from a stronger group and fight in a guild (Yee 2006). According to Ducheneaut and colleagues (2007), in WOW, higher players' levels have much more social experience regarding other players with lower levels. Players ought to collaborate as much as they can in the aim to unlock more powerful items and advance in the game.

More details are provided in appendices 7, 8, 9 and 10.

14 Conclusion of chapter I

The study of a sample of fifteen virtual worlds shows that virtual worlds are very diversified with different targets and features. We based the study on several criteria such as avatar, environment, targeted audience, means of communication, etc. Many characteristics such as the strength of the community of users and the popularity could be key success factors of virtual worlds. Nevertheless, several features could influence user's attractiveness to virtual worlds such as the ease of avatar handling, avatar customization, ease of object manipulation, good ergonomics, cheap or free add-ons, etc. Actually, users are increasingly involved in virtual worlds' developments and in some cases turning out to be true creators of virtual worlds. This

study shows that the creators of the virtual world are reflecting high level of imagination to customize the world's tastes and leisure targets. In addition, the fields of application of virtual worlds are increasingly allowing many users to meet their requirements.

People are using virtual worlds for various reasons. Some users search for a community gathered around a quest or an idea, other users see in virtual worlds a means of escaping the real life. VWs could be seen as a social network where people meet, discuss, date, etc. They could be an appropriate place for gaming with high level of challenge or a means of entertainment where one can find music, films, reproduction of places from real world, etc. They can also be a place for business where users can sell, buy and exchange virtual products. VWs could also be used for "serious" reasons like collaboration, distance learning, advertisement, attending conferences, etc.

Nowadays, games are evolving from a simple way of entertainment, to a more powerful tool for learning. Game designer are integrating serious content in the game play in the aim to achieve a set of pedagogic goals. Thanks to the powerful graphics, games are more attracting and more engaging. Indeed, serious gaming is touching many sectors such as health, military, education, etc. These applications are useful for students, practitioners, and organizations depending on the targeted field.

This chapter provides an overview about the use of VWs in several fields, the opportunities they give, same advantages and drawbacks of their use in workplace and learning. This overview constitutes a relevant basis to understand the virtual worlds from different angles, which will help us to understand collaboration in virtual worlds. Virtual project management, V-learning, social skills and leadership are relevant components directly related to teamwork. Indeed, Virtual project management could clarify the project management of a virtual team using a new technology. V-learning could help us to understand how people could deal with VWs in a serious domain such as education and training. Therefore, these domains could be helpful to understand our main subject (team collaboration).

In fact, several serious games and virtual worlds involve a collaborative dimension in their game play since users/players can work/play together to achieve team goals.

As collaboration serves at synergizing collective efforts within a team in order to achieve the game's objectives. However, not all of them include learning elements aiming to make players getting collaboration skills and best practices. Usually, WoW or America Army provides an occasion to experience collaboration with other players, but it remains non-guided and will not deal to the apprehension of collaboration skills to all players. Few researches have focused on this topic such as (Toups et al. 2009; Toups et al. 2011a; Toups et al. 2011b), they were mainly centered on coordination between players (Song and Kleinman 1994) or on simulation for decision-making in (Toups et al. 2011a; Toups et al. 2011b). Here, there is a need of a new kind of game to facilitate the learning of collaboration among a team. According to the best of our knowledge, there is no game which is specific for that goal in project management field. In this thesis, we address this gap by proposing a new collaborative serious game BestCollab.

In addition, few researches have focused on the study of team collaboration in 3D virtual worlds and their use in workspace. These new media provide many opportunities to experience richer and more engaging collaboration. Here, there is a need to study determinants of collaboration in 3D virtual worlds and the impact of this kind of media on team performance. Thus, the next chapter will focus on team collaboration in 3D virtual worlds. This study will illuminate our way to conceive a serious game by identifying determinant of team collaboration. These latter will be taken into account by the game scenarios in the aim to give a training for people willing to use virtual worlds in their workspace.

The next chapter will focus on the study of team collaboration in 3D virtual worlds.

CHAPTER II: COLLABORATION IN 3D VIRTUAL WORLDS

"Today, the vast majority of human resource managers would be surprised if a job applicant's CV were to come across his or her desk in which the applicant lists "WoW Guild Leader" as a work-related experience."

Molly Wasko, Robin Teigland, Dorothy Leidner and Sirkka Jarvenpaa

Wasko et al 2011 MISQ

1 Introduction

In the aim to follow the technological innovations, many organizations have followed the 3D trend by integrating this new media within many processes such as teamwork and collaboration. Indeed, project management is continually shifting due these changes and perpetual developments of new IT media. Even though these technologies are provided to facilitate teamwork when team members are geographically delocalized. Professional management literature encourages the use of these media and promotes them (Davidow and Malone 1992; Townsend et al. 1998). Dynamic organizations are known to be the most successful organizations since they lay on dynamic networks and IT as a primary enabler, are quickly adaptable to the markets' changing competitive landscapes and the evolving customers' requirements (Jarvenpaa and Ives 1994).

"Virtual worlds (VWs) are becoming important collaboration tools for meetings and team problem solving efforts (Wigert et al 2012, Davis et al, 2009). However, these new technologies are confronted to a set of challenges in managing online social interactions with other avatars such as the lack of cues and body language comparing to a face-to-face setting. These obstacles are likely to bring complication for teams willing to collaborate.

In the aim to understand collaboration in 3D virtual world, we identified determinants that influence team performance and categorize them into three main categories namely: technology features, individual and collective determinants.

This chapter enumerates research focusing on virtual teams and different factors influencing collaboration and performance. A large list of factors has been provided. However, we selected only most important to our research. The criteria of selection were based on the diversification of determinants from three different categories namely technological features, individual characters and collective characters. Some determinants have not been studied before while others were considered as specific to the technology. This chapter ends with a literature review about team performance in virtual teams and virtual worlds.

2 Team collaboration

"Teamwork is the ability to work together toward a common vision. It is the fuel that allows people to attain uncommon results."

Andrew Carnegie[27] (1835-1919)

The word "collaboration" derives from the Latin words "*com*" and "*laborare*" which means, "*to work together*". Researchers have defined collaboration in different ways. For example, (Levan and Vickoff 2004) states that collaboration is a social phenomenon that involves several individuals when the action of only one does not achieve the expected result. Briggs and colleagues (2006) define collaboration in terms of efforts and purpose: "*Collaboration is making a joint effort toward a group goal*" (Briggs et al. 2006) further specify this joint effort as acts of shared creation and/or discovery. Boughzala (2007) defines collaboration as a process in which two or more agents (individuals or organizations) share resources and skills to solve problems so that they can jointly accomplish one or more activities. During this process, the agents communicate with each other to coordinate their tasks.

Virtual work has been characterized as work from home, satellite offices, on the road or as ad hoc groups of professionals that team across the Internet around a common topic (Griffith et al. 2003; Nunamaker et al. 1998). Work should not "*be considered virtual (only) when all interactions were mediated by distance, with no work completed in face to face mode*", but "*along a continuum with variations in the extent of face-to-face"* and screen to screen work (Chudoba et al. 2005). Virtuality or virtualness is the extent to which a process can be virtualized (Martins et al. 2004).

Collaboration practices have evolved over time, from Face-to-Face setting to Screen-to-Screen setting and today to 3D virtual world setting. Its five characteristics/components remain the same (Vreede et al. 2009):

[27] American industrialist

Figure 1 Collaboration practice components (Vreede et al. 2009)

1. **People** (i.e. team/community members): is the main important aspect of collaboration. The human/social dimension and so team climate influences a lot the course of the collaboration process and the quality of outcomes.

2. **Process**: The type of processes has an impact on collaboration. This is related to several characteristics: number of persons, degree of formality, complexity of tasks, use of technology, etc.

3. **Facilitation**: is an important dimension introduced in the GSS (Group Support Systems) research stream to guarantee the execution of the collaboration (Bostrom et al. 1993) define facilitation as activities undertaken before, during and after a meeting of collective decision making to help the group to achieve its goals. This is related to several aspects: communication, leadership, negotiation, rewarding, etc.

4. **Information**: is an important resource (as input or output) for the act of collaboration. Information which is explicit could be extended to knowledge which implies explicit, implicit and tacit aspects. Information and knowledge could be related to both collaboration product and collaboration process, and to people interactions and relationships. Their management (capturing, sharing, application and creation) is crucial.

5. **Technology**: Collaboration technologies go from Groupware and Group Support System/ Decision Support System (GSS/DSS) in the past to Web 2.0 technologies and 3D Virtual Worlds in the future. In fact, collaboration is increasingly distributed (virtual) and thus the use of technology for that is exponential. The end-user is becoming increasingly knowledgeable and demanding. According to Sun and Teng (2012), the use of technology could be divided into three main categories namely Information Reporting System (IRS), Decision Support System (DSS) and Group Support System (GSS). Every type has a different functions fulfilled by the use

of the technology. ISR use will be related to the reporting function of the group. DSS use will consider the aspects of technology that foster decision-making. GSS use will focus on the technology aspects fostering collaboration and communication between teammates.

The technology of virtual world provides three dimensional and computer generated environments where team collaboration is facilitated through the use of shared virtual space (Nah et al. 2009). The introduction of virtual worlds as a new technology would influence all the four other components of the team collaboration: people (at the individual and team levels), process, facilitation (roles and responsibilities of the facilitator) and information (knowledge management: sharing, capturing and creation).

VW presents a new kind of interaction between users. Indeed, behavior in a VW is manifested through the interaction and communication of avatars. Prior research has shown that behaviors can affect individual performance, virtual team collaboration, and team outcomes (Jarvenpaa et al. 1998; Jarvenpaa and Leidner 1999; Zigurs 2003). It has been argued that behavior exhibited in virtual environments is different from behavior in face-to-face environments (Zigurs, 2003). Before presenting the influence of the use of VWs on teamwork, we start by providing an overview of the influence of the use of other technologies in workplace.

In the next part, we will present a literature review about Virtual Teams; it will be shown the influence of the use of technologies on teamwork. Later, we will focus on the impact of 3D virtual worlds on team collaboration.

3 Virtual teams

Teams are an important sub-unit that are gaining enhanced emphasis in organizational work (Hoegl et al. 2003; Manz and Sims 1995; Mohrman 1995; Sundstrom et al. 1990), and are increasingly considered an important element in organizational performance (e.g. (Dumaine 1994; Forsyth 1999))The turbulent business environment requires organizations to be able to create and share knowledge for gaining and sustaining a competitive advantage (Teece et al. 1997). According to Leonard and Sensiper (1998) teams represent a key element for knowledge-based organizations (Leonard and Sensiper 1998).

Organizational knowledge and expertise is often geographically distributed across boundaries (Robert et al. 2008). This means that organizations often have to create teams with members that are geographically dispersion and have to rely on electronically communication to manage their communication and coordination activities (Jarvenpaa and Leidner 1999). These teams have often been labeled as virtual. Virtual Teams (VT) are defined by Martins and colleagues (2004, p. 808) as "teams whose members use technology to varying degrees in working across location, temporal and relational boundaries to accomplish an independent task." They have a growing prevalence in the working environments attributed to the technological and organizational developments and they provide a set of business benefits (Solomon 2001). These teams are technology-enabled and can improve productivity by reducing operational costs and employing the most adequate human resources for a task (Townsend et al. 1998).

These teams are often temporarily distributed (Jarvenpaa and Leidner 1999; Kanawattanachai and Yoo 2007). The temporal attribute implies that team members may work together on a specific task or project, and may not share a past history and/or future work. In these contexts, it becomes even more important that organizations are able to acquire, deploy, and leverage their IT resources to create superior knowledge capabilities (Armstrong and Sambamurthy 1999). In fact, these contexts have been associated with various challenges like increases in social loafing (Alnuaimi et al. 2010; Dennis et al. 2012a).

VTs are becoming commonplace in many organizations because of the many benefits they provide (Gibson and Cohen 2003). The use of VT can improve productivity by reducing operational costs and increase effectiveness by employing the most adequate human resources for a task (Townsend et al. 1998). This in turns helps organizations distribute risks and costs in an appropriate (Gassmann and Zedtwitz 1999). VTs have the advantage of not only assembling members with specific educational and work experiences but also assembling members from different countries with unique cultures and perspectives on potential problems. According to Gassman and Zedtwitz (1999) there are a growing number of industrial R and D organizations employing VT and develop virtual project teams extending the concept of a traditional project by adding concurrent engineering and collaboration

techniques. VTs can be formed of a very skillful individuals for a given task independently of their locations which enhances the quality of decisions (Lipnack and Stamps 1999; Townsend et al. 1998) dealing with complex projects and achieve corporate goals (Gassmann and Zedtwitz 1999).

VTs have been studied by several researchers (Ahuja and Carley 1999; DeSanctis and Monge 1999; Gassmann and Zedtwitz 1999; Larsen and McInerney 2002; Lurey and Raisinghani 2001; Martins et al. 2004; Townsend et al. 1998). Several VTs' attributes and inputs having an impact on the team's performance have been studied such as team size (e.g. (Steiner 1972), (Leenders et al. 2003)), knowledge, technical expertise (Kayworth and Leidner 2000), technology (media richness (Daft and Lengel 1986) and media synchronicity (Dennis and Kinney 1998)). According to Burgoon and colleagues (2002) and martins and colleagues (2004), the use of a richer media leads to an increased level of performance and trust (Burgoon et al. 2002; Martins et al. 2004). Team task is considered as an important team input (Martins et al. 2004) because the task type is a critical factor that influences the speed and the speed of decision making within a team (Daly 1993; El-Shinnawy and Vinze 1998). Furthermore, if the task is ambiguous in a virtual context, the shared goal may require more much time to be achieved but this goal could have a better quality (Straus and McGrath 1994). Finally, task fitting with the team is important to be taken into account (Hollingshead et al. 1993).

Despite the potential for VTs to experience great opportunities, efficiency and effectiveness, these teams are not guaranteed to outperform physical world teams. Indeed, virtual teams face many daunting challenges such as management difficulties, maintaining individual motivation and focus, building commitment, and promoting trust (Huang et al. 2010).

According to McLeod and colleagues (1997) a minority of members were more likely to express their ideas anonymously (McLeod et al. 1997). In addition, cultural differences impacts negatively VT's communication (Kayworth and Leidner 2000) and coordination (Chudoba and Maznevski 2000) within a team.

Another widely observed phenomenon in virtual teams that is considered as very salient is the social loafing. It decreases the individual effort when performing in a

team and impact team's outcomes (Suleiman and Watson 2008). Suleiman and Watson studied argued that it occurs in teams operating in a technology-driven realm. They tried to find and study remedies overcoming it such as self-feedbacks and identifiability of group members.

At present, electronic communication is evolving towards a 3D era. For the first time, advanced technologies, have made VWs accessible to nearly everyone in an industrialized country (Chena and Chen 2009). Further, the globalization of business practices and the proliferation of collaboration technologies have catapulted the utility of VWs into the corporate world. Consequently, it is becoming more and more common for individuals to work remotely in cross-distance, cross-domain and cross-organizational virtual teams (Zolina et al. 2004). Organizations are trying to take advantage of the flexibility of technology-enabled work to create distributed virtual teams and tap into globally dispersed, cross-functional expertise and competences (Huang et al. 2010).

Despite the importance of understanding how technology facilitates effective performance in virtual teams, much of the research has focused on traditional forms of media use like email, real-time chat, phone or videoconferencing. However, organizations are adopting new forms of communication through new technologies. Yet, our knowledge of these new technologies is vastly underdeveloped. According to Hollingshead and colleagues (1993), the novelty of a technology impacts negatively team performance (Hollingshead et al. 1993). New technologies tend to reverse the direction in which control is exerted between technology and organization's actors. They help to redistribute competencies and responsibilities.

In the next part of this report, we will present team collaboration in 3D virtual worlds.

4 3D virtual worlds and team collaboration

The introduction of VWs as an innovative technology that can be utilized to enhance collaboration in the workplace has raised promising opportunities and speculation (Chandra et al. 2009; Rohall 2008; Srivastava and Chandra 2010). Owens and colleagues reported that companies such as IBM and Dell have recognized this potential and began piloting various VW projects. Such projects incorporated work

from a variety of issues including but not limited to marketing, healthcare, virtual museum tourism, e-learning, and recruitment. These projects were performed on three types of collaborative platforms within Second Life: Immersive Workspaces, Virtualis and the Alpine Executive Center. Each platform aimed to enhance intra- and inter-organizational work contexts (Owens et al. 2009). The aforementioned platforms provide many communication and work tools and features such as capabilities for editing reports, sharing comments, video conferencing (TheImmersiveSpaces.). They allow organizing conferences, social events and brainstorming (AlpineExecutiveCenter ; virtualis).

Collaborative platforms in VWs provide the advantage of reducing the need for business travel, which in turn reduces costs and protects the ecological environment. Moreover, in VWs, employees can attend internal conferences and workshops for free from the comfort of their everyday office. This convenience can reduce time wasted on travel and increase productivity during down time. Arguably, VW collaboration may not replace face-to-face collaboration, but it becomes a complementary and supplementary alternative for interpersonal interactions.

Virtual collaboration becomes indispensible in today's companies (Davis and Zigurs 2008). It aims at enhancing employees skills and improves knowledge sharing between them. By creating virtual teams, employees may collaborate. They rely on a variety of technologies for collaboration and their skill or comfort level with those technologies can vary. Unfortunately, organizations don't attach much importance to the virtual collaboration (Davis and Zigurs 2008) they required more insurance to adventure in this new collaboration tool. Moreover, advanced tools such as distributed project management software, electronic meeting systems, video conferencing suites, or "e-rooms" are still rarely used to their full potential. Besides, little guidance is available for which tools work best in different contexts (Zigurs and Khazanchia 2008). Collaboration learning benefits have been recognized in a face-to-face context but neglected in the virtual one. Thus, Virtual teams need more guidance in order to benefit from collaboration learning asset (Davis and Zigurs 2008).

Furthermore, VWs attracted the attention of Computer Supported Cooperative Work (CSCW) researchers by their potential and opportunities to support team collaboration (Meyer and Swatman 2009). Meyer and colleagues investigated

benefits, challenges and opportunities of the use of VWs in team collaboration. They suggested that an effective collaboration is probable in these environments under the respect of synchronicity of the collaboration. Moreover, they found that the specific advantages of 3D VWs do not come from the synchronicity of teamwork but there are some typical attributes of each community. Chandra and colleagues (2009) declared that VWs have opened a new promising channel for collaboration and information sharing. Indeed, experts sense the promising future of virtual world in the workplace (Chandra et al. 2009; Srivastava and Chandra 2010). Organizations are challenged to motivate their employees to utilize virtual worlds in their work tasks.

Based on the Media Synchronicity Theory, Schouten and colleagues (2010) studied how 3D virtual worlds support team collaboration. They argued that the shared environment and avatar-based interaction provided by these virtual environments lead to several benefits; aiding processes convergence in decision making tasks, leading to increase the shared understanding between different members (Schouten et al. 2010). According to Schouten and colleagues (2010), these advantages increase performance of a decision making task. This study revealed that shared understanding was higher than a text based chat, which leads to higher task performance in terms of consensus, satisfaction, and cohesion. In addition, Goh and Wasko (2010) explored the role of leadership in virtual world teams in the aim to bring insights on how to manage synchronous and highly interdependent work activities to get better outcomes.

The context of this research is to understand how virtual world could be effectively employed for team collaboration. Goh and Wasko (2010) used Leader-Member Exchange theory in the aim to study the influence of leadership on team member performance. The findings of this study established that the relationship between a leader and a team member has an influence on the degree to which the member is allocated and develops resources. Furthermore, team performance is positively related to the extent to which a team member receives or develops resources (Goh and Wasko 2009). Besides, the study established that the quantity and the type of resources have an impact on the team performance but not the leader-member relationship. Nah and colleagues (2009) studied the impact of task complexity on the teamwork in 3D VWs and hypothesized that task complexity influence team cohesion and satisfaction with team process and outcome. Task complexity lead to increasing the time taken to

achieve a task and increase as well the relative unevenness in members in terms of physical effort to achieve the task (Nah et al. 2009; Recker and West 2010).

Customization of avatars has been found very important because an avatar might be a better vehicle to escape the constraints of the physical bodies (Ducheneaut et al. 2009). According to them, users saw in their avatars a tangible embodiment of their identity or an idealized version of it. Ducheneaut and colleagues (2009) advised VWs' designer to take customization into account when designing new VWs' because it impacts the user's satisfaction about them.

VWs' high level of visualization has been found very promising for multi-sensor data fusion improvements (Hall et al. 2008). Since visualization impacts the way humans interact with data fusion systems, VWs' technology could help in improving multi-analyst collaboration (Hall et al. 2008). They could enhance data understanding by engaging the analysis as visual pattern recognition capabilities. Finally, they could provide new mechanisms for hypothesis generation and understanding (Hall et al. 2008).

Furthermore, knowledge sharing has been found to be very important for team collaboration (Cramton 2001; Gupta et al. 2009). Knowledge sharing behavior has been found to contribute to innovation which is "vital" to the enterprise performance (Kogut and Zander 1996). Actually, Chena and Chen (2009) argued that successful virtual team implementation require maximizing information sharing and reducing delays in information transfer (Chena and Chen 2009).

Research has argued that collaboration in VWs is rich and engaging thanks to their capabilities (Davis et al. 2009; Schmeil et al. 2012; Venkatesh and Windeler 2012) although these are not clearly and exhaustively identified yet. They provide high synchronicity in communications, a 3D representation of avatars affording a sense of presence and immersion (Animesh et al. 2011; Biocca et al. 2003; Walsh and Pawlowski 2002). They provide also hand gestures and facial expressions and movements allowing rich interactivity between avatars (Davis et al. 2009; Franceschi et al. 2009; Suh and Lee 2005). Consequently, they provide a more realistic visual dimension in representing work environment and provide a promising alternative to face-to-face. Furthermore, research has argued that VWs enhance collaboration and

virtual project management (Owens et al. 2009) by providing new ways to manage and overcome collaboration barriers (Davis et al. 2009). In fact, efficient and effective use of 3D VWs as a platform for team collaboration may yield a variety of benefits to an organization ranging from reducing operating costs (e.g., travel, lost work time due to excessive or untimely meetings), to enhancing productivity (e.g. speed and richness of collaboration, creativity) (Wang and Haggerty 2009).

Operationally, virtual collaboration becomes essential in today's companies; it aims at enhancing employees competences and improves knowledge sharing between them (Davis and Zigurs 2008). Despite the amount of opportunities provided by these virtual environments, the idea of using them in professional settings is still surrounded with much hype (Davis and Zigurs 2008; Owens et al. 2009; Venkatesh and Windeler 2012) even if many encouraging results have been reported such as IBM experience (LindenLabs 2009). Actually, nowadays organizations are hesitating about using VWs since their impact on team collaboration is not examined in depth (Davis et al. 2009; Davis and Zigurs 2008). They are requiring more insurance to adventure in these new collaboration tools (Davis and Zigurs 2008; Wasko et al. 2011). While some earlier researches have shown that VW collaboration represents a successful alternative to traditional face-to-face collaboration, VWs interaction could also engender misunderstanding, acceptance issues (Bessière et al. 2009), intra community conflicts (Cahalane et al. 2010), violation of group norms (Owens et al. 2009), and difficulty building trust between users (Bessière et al. 2006; Schroeder 2008; Yee et al. 2007). Indeed, this bolsters the need to analyze such usage in various settings and among many groups.

Actually, one of major reason about hype around VWs is that people are not developing a real wave of innovation in VWs, they are trying to replicate real world experience into the virtual one (Wasko et al. 2011). Collaboration is impacted by the introduction of a new technology (Vreede et al. 2009), and it has its own specificities. Thus, we cannot see it the same as collaboration in a face-to face setting or in a screen-to-screen one (Venkatesh and Windeler 2012). Virtual teams need more guidance about VW technology usage in order to benefit from collaboration asset (Davis and Zigurs 2008).

Some researchers specializing in law, public politics, and economics have raised questions addressing regulation and governance of VWs, and the emerging virtual economy (Castronova 2006; Lastowka 2005; MacInnes 2006; Malaby 2006). For instance, some authors have addressed the issue of whether "virtual properties" that are bought and sold in VWs should be considered property in the legal sense (Mennecke et al. 2007). Furthermore, some researchers addressed the question of identity theft and fraud in VWs (Lastowka and Hunter 2004; Roche and Nostrand 2007). Mennecke and colleagues (2007) argued that more research is needed to understand these issues and to find remedies for them.

Nevertheless, collaborating in such environments is likely to be more challenging than face-to-face. Indeed, the lack of body language and rich communication between team members is considered as a challenge to the collaboration process (Olson and Olson 2000; Yee et al. 2007). The Lack of face-to-face could lead to several social problems such as confusion, misunderstandings, interpersonal conflict, intra community conflicts (Cahalane et al. 2010), violation of group norms, and difficulty building trust between users (Bessière et al. 2006; Schroeder 2008; Yee et al. 2007).

Moreover, technical challenges of VW collaboration are adding more complexities to the collaboration, thus the experience of using these environments could have an impact on the team outcomes. In fact, technical expertise and experience of using technologies has been found to positively influence the VT's success (Kayworth and Leidner 2000). MUVEs are powerful and malleable but it can be difficult and time consuming to learn how to use them for new users (Bulkeley 2007; Yee et al. 2007). Furthermore, when struggling to understand how this new VW software functions, users could loose of their performance and satisfaction with the technology (Bulkeley 2007).

In addition, VW software requires high technical capacities which can burden the computer and cause many problems such as operating system delays and shutdowns (Bulkeley 2007). Chandra and colleagues (2010) argued that even if VWs are considered as new relevant channel for workspace collaborations, several firms which made strong entrance into VWs' utilization are stepping back. This reaction is due to the limited user response to these new environments.

Many challenges have been raised due to the increasing use of virtual worlds in the work office and in the collaborative tasks (Bergin et al. 2010). The gap raised in this research is the issue of leveraging these environments to promote and induce effective work performance.

In the aim to study collaboration in 3D VWs, we firstly start by characterizing it by a set of determinants and then establish research models. Determinants are factors that are considered decisive and significantly influencing. In the next part of this chapter, we will present determinants from the literature of VWs.

5 Determinants of team collaboration in 3D virtual worlds

The literature of VWs considers a set of factors impacting team collaboration. Venkatesh and Windeler (2012) studied the relationship between a team's disposition towards IT, their general disposition (i.e., personality), and their virtual world use in influencing team cohesion and performance. Chandra and colleagues (2012) studied the motivations for adaptive use intention when using VWs for team collaboration. They identified cognitive absorption and user trust as the mechanisms leading to the individual level adoption decision (Chandra et al. 2012). While Nardon and Aten (2012) conducted a qualitative study targeting assessment of a VWs as a medium in collaborative work (Nardon and Aten 2012). Another relevant research conducted by Schmeil and colleagues (2012) reporting on the development and the application of a structured approach for the combined design of 3D virtual environments and the collaborative activities within them (Schmeil et al. 2012).

Suh and colleagues (2011) studied the impact of customizing avatars to be close to the users' actual appearance on their behavior in VWs. This study focuses on the antecedent leading to customization and the implication of such attitude on users' willingness to experience and evaluate some business areas related to users' lives in the real world (Suh et al. 2011). In the same frame, Animesh and colleagues (2011) studied the impact of the technological and spatial environment on the users' intention to purchase virtual products (Animesh et al. 2011).

The following table provides a list of all determinants found in the literature. In spite of rich amount of investigations conducted on VWs, some relevant constructs such as social loafing, knowledge sharing and knowledge application have not been

studied yet. In addition, two specific features of 3D VWs namely object manipulation and customization still not studied in workspace.

Construct	***Initial reference***	***Reference in VWs***
Leadership	(Bass 1985)	(Goh and Wasko 2009; Munkvold and Zigurs 2007)
Empowerment	(Spreitzer 1995)	(Goh and Wasko 2009)
Decision making	(Connolly et al. 2003)	(Schouten et al. 2010).
Flow	(Csikszentmihalyi 1990)	(Hassell et al. 2009)
Immersion	(Slater et al. 1996)	(Damart et al. 2010; Guadagno et al. 2007)
Trust	(Boon and Holmes 1991)	(Chandra et al. 2012)
Computer self-efficacy	(Compeau and Higgins 1995)	(Venkatesh and Windeler 2012)
Agreeableness	(Barrick and Mount 1991)	(Venkatesh and Windeler 2012)
Conscientiousness	(Barrick et al. 2001)	(Venkatesh and Windeler 2012)
Extraversion	(Digman 1990)	(Venkatesh and Windeler 2012)
Openness to experience	(McCrae and Costa 1997)	(Venkatesh and Windeler 2012)
Neuroticism	(Digman 1990)	(Venkatesh and Windeler 2012)
Personal innovativeness with IT	(Barrick and Mount 1991)	(Venkatesh and Windeler 2012)
Computer playfulness	(Webster and Martocchio 1992)	(Venkatesh and Windeler 2012)
Socialization	(Clausen 1968)c	(Jung and Kang 2009)
Team cohesion	(Festinger 1950)	(Venkatesh and Windeler 2012)
Leader-member relationship	(Graen and Uhl-Bien 1995)	(Goh and Wasko 2009)
Task complexity	(Wood 1986)	(Nah et al. 2011)
Technology usage	(Burton-Jones and Straub 2006)	
Knowledge application	(Alavi and Leidner 2001)	
Co-presence	(Slater et al. 2000)	(Ferratt and Hall 2009; Hassell et al. 2009)
Knowledge sharing	(Davenport and Prusak 1998)	
Object manipulation	(Robinett and Holloway 1992)	
Customization	(Kobsa et al. 2001)	(Teng 2010) studied in the context of gaming WOW
Social loafing	(Latane 1979)	
Cognitive	(Agarwal and Karahanna	(Chandra et al. 2009; Chandra

absorption	2000)	et al. 2012; Goel et al. 2011)
Density	(Blau 1977)	

Table 3 Findings from the literature: constructs influencing team collaboration in 3D virtual worlds

6 Choice of determinants

The list of constructs is wide; however, our study will focus on a restricted list of them.

First, we started by positioning the capacities of VWs by comparing it with a voice communication media. This first quantitative study is dealing with a comparison between the use of Skype and the use of Second life on team performance. We based our selection about the determinants from the literature namely virtual co presence, density and cognitive absorption. Indeed, these three determinants are perceived in both technologies. The comparison of these two media is based on the capacities of each of them to better place for work.

While our second study was mainly focused on VWs, we used determinants from three different categories (technological, individual and collective).

Our selection of determinants was based on four main criteria:

- Determinants which are specific to virtual worlds such as Object manipulation and Customization.
- Determinants which are perceived with influential impact on virtual worlds such as Co-presence and Cognitive absorption.
- Determinants which are not studied in the virtual world context such as knowledge application, density, social loafing and knowledge sharing.
- Determinants which were highlighted by the literature to have a strong impact in collaboration in virtual teams or in face-to-face setting such as knowledge sharing, social loafing and Technology usage.

Determinant	**Specific feature of VWs**	**Having strong impact on collaboration in VT and face-to-face setting**	**Context of the study in virtual worlds**

Knowledge sharing	No	Yes	Not studied in 3D virtual worlds
Customization	Yes	---	(Teng 2010) studied but in gaming context only
Knowledge Application	No	Yes	Not studied
Object manipulation	Yes	---	Not studied
Technology usage (GSS)	No	Yes	Not studied
Density	No	Yes	Not studied
Individual performance	No	Yes	Not studied
Co-presence	No	No	(Ferratt and Hall 2009; Hassell et al. 2009) However, no study is comparing co-presence in 3D virtual worlds and 2D videoconferencing.
Cognitive absorption	No	No	(Chandra et al. 2009; Chandra et al. 2012; Goel et al. 2011) However, no study is comparing cognitive absorption in 3D virtual worlds and 2D videoconferencing.
Social loafing	No	Yes	Not studied

Table 4 Determinants selection grid

7 Categorization of the determinants

In our choice, we have taken into account to bring together determinants from three categories: technology, individual and collective. In fact, we are aiming to have complete landscape about categories that can influence team collaboration. Moreover, some determinants could have a negative impact on performance such as social loafing while other have a positive effect such as customization. These effects will be studied in our quantitative studies which will be presented in two chapters VI and VII.

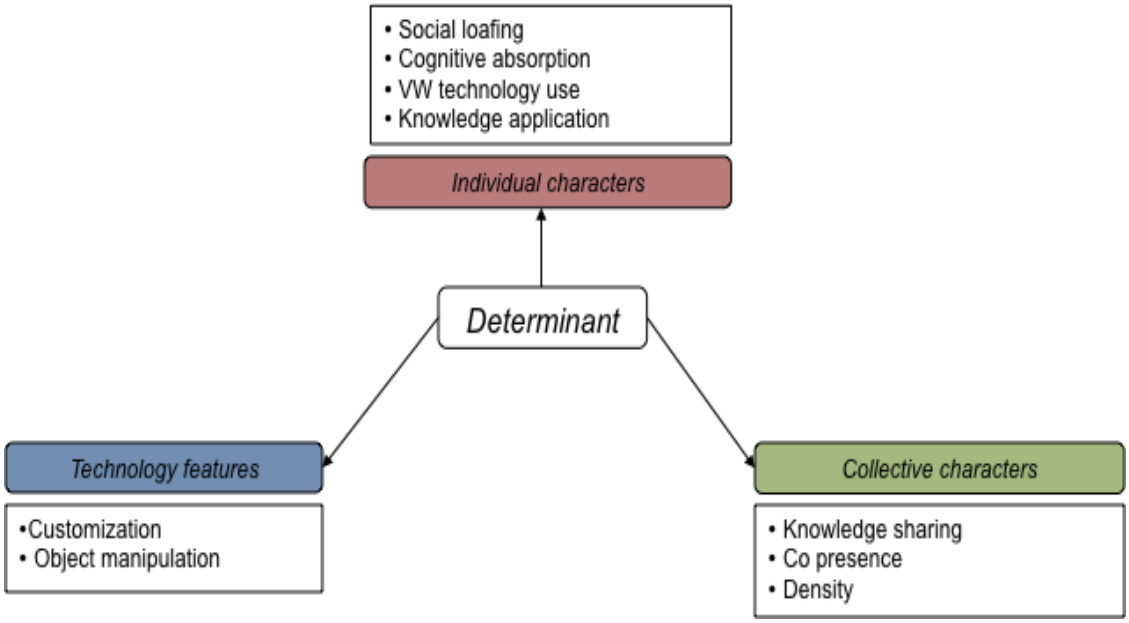


Figure 2 Classification of selected determinants into three categories

The study of these determinants and their eventual impact on team collaboration and specially team performance will be our target of this research. We aim to determine the relationship between VWs, team collaboration and team performance. Thus, we will use the identified determinants to build two models. We have explored VWs and team collaboration in these environments; hence, in the next part we will focus on team performance in the literature.

8 Team performance

Several researches have focused on performance of virtual teams. Performance could be measured basing on team's effectiveness. In instance, Lurey and Raisinghani (2001) used three main categories of criteria to measure the effectiveness of a team: the level of productivity, capacity for self learning and self improvement of team functioning and finally the team's ability to satisfy individual team members (Lurey and Raisinghani 2001). These criteria are the same ones presented by (McGrath 1984).

Team performance typically focuses on task-related outcomes (Pinsonneault and Kraemer 1989). Task-outcomes are criteria related to task achievement such as quality, effectiveness or efficacy. Kankanhalli and colleagues (2006) considered that performance is related only to the task quality (Kankanhalli et al. 2006). Member's

satisfaction could be also considered as relevant to assess the team performance (Hassell et al. 2009).

Team effectiveness has been found as a predictor construct to assess team performance (McGrath, 1984; Lurey and Raisinghani, 2001). Research provides main categories of criteria to measure the effectiveness of a team such as productivity level, capacity for self-learning and self-improvement of team functioning and finally the team's ability to satisfy individual team members. In addition, it has been argued that team cohesion is a relevant antecedent to team performance because it increases the team members' commitment to their tasks (Langfred 1998). In addition, task outcomes have been considered as important factor in team performance evaluation (Pinsonneault and Kraemer, 1989). Task-outcomes are criteria related to task achievement such as quality, effectiveness or efficacy. Kankanhalli and colleagues (2006) considered that performance is only related to the task quality.

According to virtual teams' literature, many definition of performance exist. However, we will not use them all in our research, our choice will be set regarding the specificities of the study. Hence team performance could be factual measured through outcomes or perceived measured as perceived from team members. In this thesis, we used a factual measurement of team performance in our first qualitative study were we have compared the performance of students using Second life and Skype (as all teams are doing the same task in the same time). While, in our second study we have used a perceived measurement of performance from respondents point of view (as every participant is wokring on different tasks).

9 Conclusion

As technologies matured and became more widely available, more people joined VWs, and the understanding of presence evolved to include the sense of being with and interacting in symphony with others in a virtual place (Slater et al. 2000). 3D virtual worlds have been developed and spread profiting from the technology development mainly Internet availability (Davis et al. 2009). They offer potential virtual collaboration that could exceed traditional technologies such as text-based ones (Schouten et al. 2010). This potential could promote to more engaging collaboration through the VWs' interesting capabilities which are not explored in

depth. In fact, collaboration in MUVEs are mixing entertainment and intellectual purposes which tends to intrinsically motivate users (Bessière et al. 2006).

In the aim to bring an in deep understanding about collaboration in 3D virtual worlds, we characterized it with a set of relevant determinants. Determinants could be related to the technology of 3D VWs such as customization or object manipulation, or related to the team like knowledge sharing and density or related to the team member social loafing. Determinants could have a negative effect on the collaboration process, so they are called inhibitors (for example social loafing). Others determinants have a positive effect on collaboration or enabling it so they are called enablers. One of the aims of this research is to extract determinants and find the relationships that may exist between them. The selection criteria of these determinants are very precise and well targeted basing on references from the literature and an exploratory study conducted with experts. These determinants will be the subject of use in two quantitative studies about virtual worlds which will be detailed in two separate chapters. These two studies were focusing team collaboration in 3D virtual worlds and the impact on team performance.

CONCLUSION OF THE LITERATURE REVIEW

The literature review shows that the impact of use of virtual worlds in workspace on team performance still not sufficient to encourage organizations to adopt them. Several determinants that are salient to collaboration are not studied. First, we need to present strengths, weaknesses, opportunities and threats of the use f virtual world for team collaboration. This study will help us to filter more determinants. Quantitative studies will try to bring insights about the impact of each selected determinant on team collaboration and performance.

The literature shows the lack of training tools for people who want to understand collaboration in 3D virtual environments. A serious game presenting collaborative scenarios will be useful to meet this need.

The understanding of collaboration in 3D virtual worlds will be a starting point in the design of collaborative scenarios.

Several researches have studied the virtual collaboration, many theories have been mobilized and many factors influencing this kind of collaboration have been reported. In the next chapter, we will give literature review about theories that influenced this research and propose a methodological framework to meet our research gap and business need.

CHAPTER III: THEORETICAL BACKGROUND

“Who loves practice without theory is like the sailor who boards ship without a rudder and compass and never knows where he may cast.”
Leonardo da Vinci (1452-1519)

1. Introduction

Both traditional and online-virtual use technologies were presented in the literature in order to analyze and understand individuals and teams' use and behavior towards these technological supports. Knowing the nature of technology to use is crucial for organizations (Martins et al, 2004). Actually, several theories have been presented in the literature in the aim to analyze technology usage in workspace.

Our starting point to understand the subject is the literature which provided a large set of theories. However, we will try to focus on those that are valuable in the context of this thesis. We are interested in theories that try to explain the potential of technologies to support social interaction, theories that deal with the importance of technology features to support teamwork. We are interested in theories that explain these factors that urge people to use and adopt technologies. Finally, theories that try to explain the correlation between technology use and performance.

2. Social presence theory (Short et al. 1976)

It is a seminal theory of the social effects of communication technology. Its main concern is with telephony and telephone conferencing (the research was sponsored by the British Post Office, now British Telecom). It argues that the social impact of a communication medium depend on the social presence it allows communicators to have. Social presence is defined as a property of the medium itself: the degree of acoustic, visual, and physical contact that it allows. The theory assumes that more contact will increase the key components of "presence": greater intimacy, immediacy, warmth and inter-personal rapport. As a consequence of social presence, social influence is expected to increase. In the case of communication technology, the assumption is that more text-based forms of interaction (e-mail, instant messaging) are less social, and therefore less conducive to social influence. Hence, virtual co-presence is a salient construct to understand the impact of the technology on team performance.

3. Media richness theory (Daft and Lengel 1986)

It shares some characteristics with social presence theory. It posits that the amount of information communicated differs with respect to a medium's richness. The theory

assumes that resolving ambiguity and reducing uncertainty are the main goals of communication. Because communication media differ in the rate of understanding they can achieve in a specific time (with "rich" media carrying more information), they are not all capable of resolving uncertainty and ambiguity well. The more restricted the medium's capacity, the less uncertainty and equivocality it is able to manage. It follows that the richness of the media should be matched to the task so as to prevent over simplification or complication. According to Martins and colleagues (2004), media richness is crucial to team performance since richer media are able to facilitate communication and team collaboration. Several technologies are able to afford the use of a variety of languages, to provide a high degree of personalization and to perform multiple exchanges through various channels of communication (written information, verbal and physical). Agarwal and Karahanna (2000) argued that perceived media richness of technology is positively and significantly related to cognitive engagement for which derives the concept of cognitive absorption.

4. Media synchronicity theory (Dennis and Kinney 1998)

It redirects richness theory towards the synchronicity of the communication. Synchronicity is defined as a “state in which individuals are working together at the same time with a common focus.” MST focuses on the capability of media to support synchronicity. It posits that communication will be enhanced when the synchronicity a given medium can support appropriately matches the synchronicity that a communication process requires. This theory assumes that the media should cover five features, namely: the immediate return (immediacy of feedback) and therefore the ability of media to ensure rapid bidirectional communication, a variety of symbols (Symbol Variety) relative to all the possibilities that the media offers to codify and represent the information; parallelism (Parallelism), which is reflected in the number of synchronous conversations that can occur simultaneously; regulation (Rehearsability) which is the fact that media allows an actor to reformulate or adjust his message when it is about to be sent and finally test reprocessing (Reprocessability) which means that actors can reconsider the archived messages. This theory conceptualizes a high richness communication medium as one that best provides the set of capabilities required by the situation (in terms of the task and social context) (Maruping and Agarwal 2004)

5. Technology Acceptance and Use theories (Davis 1989; Venkatesh et al. 2013)

Technology Acceptance Model (TAM) models how users come to accept and use a technology. According to this model, when a new technology is presented to users, a number of factors influence their decision on the rejection or the adoption of this technology namely:

- ***Perceived Usefulness (PU):*** "the degree to which a person believes that using a particular system would enhance his or her job performance".
- ***Perceived ease of use (Peou)***: "the degree to which a person believes that using a particular system would be free from effort".

The UTAUT (Unified Theory of Acceptance and Use of Technology) explains the user intentions to use an information system and subsequent usage behavior. The theory argues that four key constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions) are direct determinants of usage intention and behavior. Gender, age, experience, and voluntariness of use are posited to mediate the impact of the four key constructs on usage intention and behavior.

6. Adoption and use of virtual worlds

Research has asked questions about the adoption of virtual worlds and why people are motivated and have the intention to use them. Indeed, many factors have been found to foster their adoption. Several researchers have focused on exploring the user's intention to use VWs (Goh and Yoon 2010; Pike and Murphy 2009; Shen and Eder 2008; Srivastava and Chandra 2010; Vogel et al. 2008). They used the lenses of the acceptance theories like Technology Acceptance Model (TAM) (Davis 1989)and unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al. 2003).

According to Shen and Eder (2008) the perceived ease of use has stronger effect on user's intention than the perceived usefulness of virtual world. It is found to be significantly affected by the perceived enjoyment of participating in 3D VWs. Vogel and colleagues (2008) established a comparison between two influential virtual worlds namely HiPiHi and Second life. This study aimed at understanding key features facilitating the acceptance of the Chinese VW HiPiHi.

Goh and Yoon (2010) suggest new "important hedonic factors" complementing ones proposed in UTAUT. Indeed, they studied the influence of inhibitors that may lead to the rejection of virtual worlds. Goh and Yoon (2010) suggested that existing technology acceptance models should incorporate hedonic influences mainly when examining the acceptance and diffusion of a technology.

Srivistava and colleagues (2010) examined theoretically the role of trust in motivating users to use rich virtual communication medium for collaboration (Srivastava and Chandra 2010). They established that perceived social presence and perceived structural assurance play important roles for fostering users trust to use VWs. Moreover, there is a significant relationship between user trust to extrinsic and intrinsic motivations. These two types of motivations influence the behavioral intention to utilize virtual worlds.

Pike and Murphy (2009) studied the role of sex, psychological trait and computer self-efficacy on user's intention to use VWs (Second Life). The study suggested that these three factors are significant and influence the intention to use VWs.

Goel and Prokopec (2009) explored the implication of social aspects enabled by 3D VWs on the user' intention to use them. Several factors that may have an important role have been highlighted such as social awareness, social interaction, and social quality. The results suggested that perceived social interactions and social awareness influence positively cognitive absorption felt when using a VW (Goel and Prokopec 2009). These two factors are impacted by the user's social skills and his/her perception of the social quality of the technology. Cognitive absorption significantly predicts the satisfaction with VWs and the intention to reuse them. Chandra and colleagues (2009) supported that cognitive absorption and trust played a significant role in the usage of VWs in a collaborative context (Chandra et al. 2009).

Jung and Kang (2009) and Li and colleagues (2009) studied users' motivation to use VWs. Jung and Kang (2009) demonstrated that people connect themselves on 3D VWs in order to satisfy their social and hedonic needs and to escape the real world constraints (Jung and Kang 2009). Li and colleagues (2009) suggested that member's virtual behavior was a response of them to fulfill their interpersonal relationship needs (Li et al. 2009).

Brown and colleagues (2004) focused on computer anxiety and communication apprehension in the aim to study their influence upon users' attitudes toward the use of computer-mediated communication (CMC). They suggested that computer anxiety, oral communication apprehension, and CMC familiarity contribute to CMC anxiety, though written communication apprehension does not have impact on CMC anxiety (Brown et al. 2004).

Some researchers such as (Assmann et al. 2010) (Chen et al. 2010a; Goh and Wasko 2010) studied the MMOG dependency. Chen and colleagues (2010) proposed three predictive models of MMOG dependency and tested them empirically using a survey of online game players. They found that multimedia realism for social interaction could serve as an original antecedent that could influence other mediating factors to cause MMOG dependency. According to Chen and colleagues (2010), mediating factors derive from Uses and Gratifications Theory. They included the participation in a virtual community, the diversion from everyday life and a pleasant aesthetic experience. This study argued that participation in a virtual community has a significant positive relationship with MMOG dependency. Aesthetic factor has a modest negative impact. Finally moderator analyses assumed that gender and playing frequency don't have any significant influence on MMOG dependency, in the same time, playing experience is a significant moderating factor for this dependency.

Day and colleagues (2009) applied the Diffusion of innovations theory to address factors that influence the adoption of 3D web sites and to focus on the paths that may lead to their success. Authors discussed the transformation of the web into 3 dimensional spaces. They argued that Second Life or other 3D virtual world would grow to become like the Internet today if there will be common grid protocol and access to these environments will be open to everyone. There is a new 3D web browser called ExitReality which is an attempt to render a two dimensional web into a 3D one (Day et al. 2009). This web site functions as VW, it is inhabited by avatars representing persons and we have the possibility to encounter others persons surfing in the same way. Day and colleagues (2009) explored the feasibility, the potential, and the challenges to create such a 3D web site. They assumed that rapidly-expanding social networking such as Facebook or Myspace will have an encouraging role for this kind of Web site, or maybe this will modify the vision by making site-socialized virtual rooms like Yoville.

7. Task-technology fit theory (Goodhue and Thompson 1995; Zigurs and Buckland 1998)

It holds that IT is more likely to have a positive impact on individual performance and be used if the capabilities of the IT match the tasks that the user must perform. Although the Goodhue and Thompson (1995) model operates at the individual level of analysis, Zigurs and Buckland (1998) present an analogous model operating at the group level. This theory could be mobilized to understand the task fit in VW environment at the individual and the group level.

8. Learning theories

As serious games provide a "learning by doing" way to apprehend new skills. According to Kolb (1984), this type of learning is considered as experiential. Several theories are interested to study learning specificities, in this research we have mobilized three ones that explain the learning by doing experience and the role of learning goals in the serious gaming.

Experiential Learning Theory (Kolb 1984)

This theory is studying the cycle of learning by doing experience. Kolb (1984) has proposed four main steps in this kind of learning, respectively (Kolb 1984):

- Concrete experience: This is the first step in Kolb's cycle. It starts with doing something in which the individual, team or organization are assigned a task. According to authors, key to learning is active involvement in the experience. We cannot learn by the simple act of reading or watching.

- Reflective observation: In this second step, one takes time-out from the experience of doing something and steps back in the aim to review what has been done.

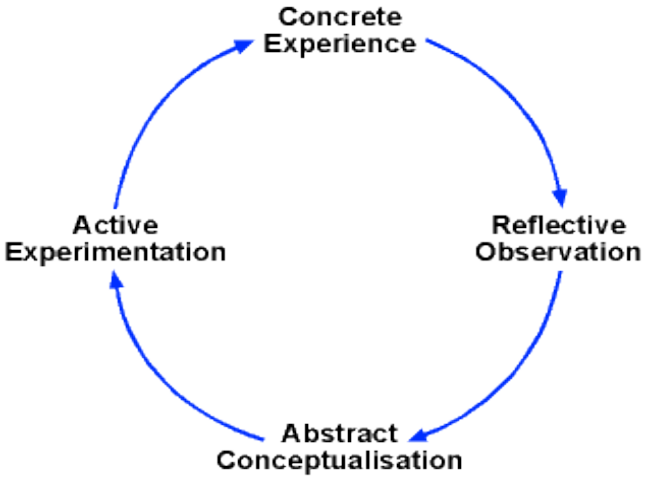


Figure 3 Kolb cycle

- Abstract conceptualization: At this step, the learners capitalize what they have learnt by comparing their new state of knowledge with their start point.
- Active experimentation: Once the learners integrate the new knowledge and put it into practice the appropriate context.

Social cognitive theory (Bandura 1986)

This theory is based on the assumption that people learn by imitating and using their cognitive capacities. They can learn when seeing others behaving in a certain way. People can expand their knowledge and apprehend new skills. According to Bandura (1986), three aspects are highlighted in this theory (Bandura 1986):

- The development of people's cognitive social and behavioral competences.
- The cultivation of people beliefs in their capabilities. So they will use their talents effectively.
- The enhancement of people's motivation through goal systems.

Self-determination theory (Ryan and Deci 2000)

Self-Determination Theory (SDT) is an important theory of motivation (Ryan and Deci 2000). It focuses mainly in issues related to extrinsic and intrinsic motivation (Ulicsak 2010).

Three relevant needs of the learner are studied in this theory:

- Competence evolving: learner needs to feel improvement.
- Relatedness: players need to interact, to be connected to, and experience caring for others.
- Autonomy: is the universal need to be relevant for the project and act in a harmony with one's integrated self.

According to authors if these needs are satisfied, people will be motivated and evolve optimally.

Motivation is classified into two main categories:

- Intrinsic motivation: This kind of motivation occurs when the performance of a task is mainly because of enjoyment and fun.
- Extrinsic motivation: This kind of motivation occurs when a person tends to perform a task mainly because this action will yield to rewards or benefits.

These three theories will be mobilized in the design process of our serious game BestCollab.

9. Mobilization of theories

Theory	Study	Manner
Technology Acceptance and Use theories	First quantitative study /Second quantitative study	2 dimensions of determinants (technological and individual)
Media synchronicity theory	First quantitative study	2 dimensions of determinants (technological and individual)
Social presence theory	First quantitative study	Sense of presence with others when using a technology. Three dimensions of determinants (technological, individual and collective)
Media richness theory	First quantitative	Importance of communications

	study	means and technology assets in impacting collaboration.
Task-technology fit theory	Second quantitative study	Impact of technology on individual performance.
Experiential Learning Theory	Designing the serious game	Learning by doing experience in the game
Self-determination theory	Designing the serious game	Learning by doing experience in the game
Social cognitive theory	Designing the serious game	Learning by doing experience in the game

Table 5 List of theories

10. Conclusion

Theories provided us the possibility to identify the three levels of analysis : technological, individual and collective. Some theories aim at clarifying the impact of technology and its capabilities on collaboration such as social presence, media richness and synchronicity. Therefore, in the light of these theories, we could understand the technological side of virtual collaboration and the impact of VWs' introduction in a collaborative context.

As media focusing theories mentioned above highlights the importance of the technology in collaboration, we have considered a category of determinants related to the specificities of the technology. The theories of acceptation and use of technology were highlighting the importance to consider the VW technology usage in our study and to think about the levels of interaction namely: human level, human-computer interaction and team level.

The learning by doing theories helped us to integrate learning goals into the game play. Each theory brings relevant elements (such as competence evolving) to enrich the game play. For example, self-determination theory highlighted the importance of self-improvement feeling when playing the game, which will be experienced by the augmentation of the score, the experience with the game and the advancement in stages.

CHAPTER IV: METHODOLOGICAL FRAMEWORK

"Art and science have their meeting point in method."
Edward G. Bulwer-Lytton[28] (1803-1873)

[28] Politician and poet.

1. Introduction

In the aim to answer the research questions presented above, we designed a methodological framework based on Hevner and colleagues (2004) research. This framework combines between design science and behavioral science trying to have more significant contribution in the IS field (Hevner et al. 2004). It brings together mixed methods (qualitative and quantitative) in order to have deeper insights and more rigorous results (Venkatesh et al. 2013). In this section of the dissertation, we will present IS research Framework (Hevner et al 2004) and explain our methodology.

2. IS research framework

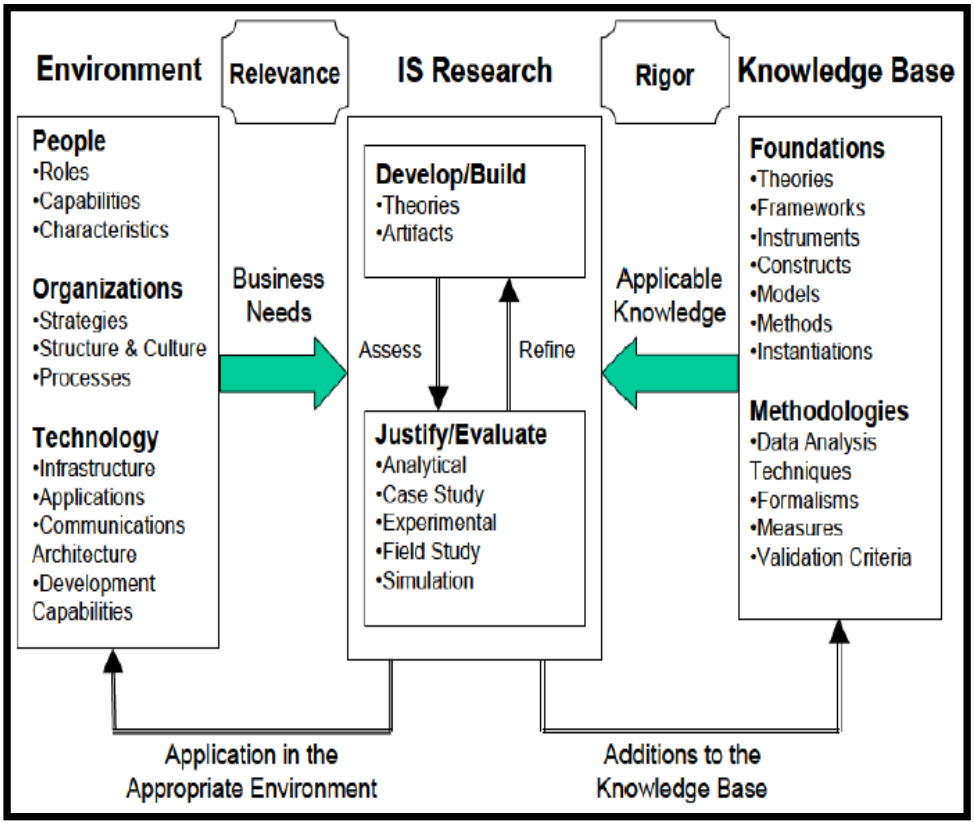


Figure 4 IS research framework Hevner et al. 2004

Research in information systems is characterized mostly by two different but complementary paradigms: behavior-science and design-science. Both are foundational in the IS discipline. Behavior-science deals with development and verification of theories explaining and predicting human or organizational behavior. It has its roots in natural science research. Its theories inform researchers and practitioners in IS community of the interactions among IS actors (people, technology

and organization). These interactions must be managed in order to achieve IS goal (improving effectiveness and efficiency of an organization). Design-science paradigm allows creating new and innovative artifacts in order to extend human or organizational boundaries. It's a problem-solving paradigm having its roots in engineering and the sciences of the artificial. Artifacts generated are impacted and impact theories from behavioral science.

Hevner and colleagues (2004) argue that significant contribution for IS research could be done by engaging the complementary research cycle between design-science and behavioral science. Both are not dichotomous and inseparable in IS research. Indeed, artifacts are implemented in an organizational context and theories from behavioral science are used to predict or explain phenomena occurring in respect to these artifacts. Authors focus on the performance of design-science research in information systems. They present a concise framework and some guidelines for understanding, executing and evaluating research. They conclude that performing high-quality design-science research call for synergistic efforts between both design-science and behavioral science. Furthermore, design is a process (*world as acted upon: set of activities*) and a product (*world as sensed: artifact*). The artifact is made to address a problem and to solve it, but an evaluation step is relevant in order to improve quality of the product and the design process

This framework represents the environment like the confluence of (people, technology and organizations) and this environment defines the problem (business need) space. IS research is composed from activities like evaluate/justify and build/develop. Indeed, two phases are identified after detecting a business need (a problem). First, behavioral science addresses research through the development and justification of theories that predict or explain the phenomena related to the business need. Design-science addresses research through the building and evaluation of artifacts designed to face the business need. Knowledge base provides the raw materials from and through which IS research is accomplished like methodologies and foundations. Methodologies provide guidelines used in the justify/evaluate phase. Rigor is achieved by appropriately applying existing foundations and methodologies. In behavioral science, methodologies are typically rooted in data collection and empirical analysis techniques. In design science, computational and mathematical

methods are primarily used to evaluate the quality and effectiveness of artifacts; however, empirical techniques may also be employed.

In the words of Hevner et al.'s IS research Framework (2004 p. 80), to combine relevance and rigor by meeting a business need with applicable knowledge and so to maximize the resulting artifacts' relevance and applicability.

The methodology Recherche-Ingénierique (Chanal et al, 1997) is a methodology that allows the researcher to take the position of an engineer and solve a problem using Applied science/ Engineering. The difference between this methodology and design science cycle is that the researcher in the Recherche-Ingénierique designs, tests, and evaluates artifacts as a precise solution to a problem or need. The design cycle science researcher provides a generalized solution to a class of problems. The solution will be iterated and refined by looping between behavior science and design science.Methodological framework

The methodological framework is based on the Hevner's and colleagues (2004) Information System (IS) research framework. The idea of this framework is to combine behavioral science and design science in the aim to study the impact of team collaboration in VWs on performance.

Given the research gap of studying the impact of team collaboration in 3D virtual worlds on team performance, research models gathering determinants linking VWs technology, team collaboration and team performance is required. Such models are relevant to consider virtual team collaboration determinants and to understand their impacts on each other and on performance. Starting from the literature and/or exploratory studies we extract determinants and then we design these research models. The research models will be assessed by quantitative studies conducted with specific collaborative scenarios. The design science artifacts are the collaborative scenarios that are intended to respond to a specific business need. In fact, the business need addressed here is to provide a training to team members to collaborate in 3D virtual environments via collaborative scenarios taking into account determinants considered in research models Scenarios are parts of a serious game designed basing on theories. Once lab experiments or field studies are conducted using these

scenarios, qualitative questionnaires are conducted in the aim to have insights from the participants and then to refine the research models.

Behavioral science

From the behavioral science side, laboratory experiments and field studies are conducted combining qualitative and quantitative approaches. This mixed methodology is called "third methodological paradigm". According to Venkatesh and colleagues (2013), combining both qualitative and quantitative research methods can help to develop rich insights on one domain of interest. Researchers encouraged such combination because it leads to deeper understanding.

- Qualitative approach serves to explore 3D virtual collaboration and identify determinants that will be involved in the research models. Basing on the literature, a rich background about determinants of collaboration in virtual teams and remote work has been found. Thus research models are established basing on these determinants through the above propositions, determinants that are characteristics of 3D virtual Worlds and other factors that may influence the process of collaboration (control variables such as age, team size, task complexity, experience with VWs, etc).

  In this thesis we have conducted one exploratory study, we asked our panel of experts to identify challenges and opportunities organizations may face when using VWs in a collaborative context. We conducted a SWOT analysis from a brainstorming session as a preliminary exploratory study with graduate management students. This SWOT analysis is intended to present possible perceived Strengths, Weaknesses, Opportunities, and Threats of team collaboration in VWs. After data analysis, we noticed a set of constructs that seem to be relevant to effective collaboration in VWs. They are factors may positively or negatively influence team collaboration in VWs, such as social loafing, knowledge sharing, object manipulation etc. Some of these factors are essential to effective collaboration, and all have an obvious impact by enabling or inhibiting individuals or teams when collaborating. Enabling factors include opportunities such as knowledge sharing, and others are inhibitors such as social loafing.

This study helped to identify a set of determinants from experts' point of view that are used in our quantitative studies.

- Quantitative approach serves to study the assumptions of research models. A lab experiment and a field study have been conducted using structural equation models (SEM).

  Basing on the literature and the exploratory study, we designed two research models. First, we conducted a comparative study between Skype use and Second Life use (Lean media, communication only vs. Rich media, virtual co-presence/world). The purpose of the experiment was a Brainstorming task aiming to deliver a SWOT analysis that evaluates the introduction of a new Information Technology in a given company. This study serves at identifying common features of virtual worlds in comparison with Skype.

  Second, we designed a second model that gathers determinants specific to virtual worlds mainly object manipulation and customization. A second quantitative study has been conducted with experts using 3D virtual worlds in their workspace. The study allows assessing the impact of VW use and social loafing on knowledge sharing and knowledge application in the 3D virtual world setting.

Study	Characteristics	Method
First study	•Skype Vs. Second Life •Precise task: SWOT Analysis •Non-guided collaboration •Lab Experiment	•Quantitative •60 teams, 183 students •Average age 21.27, 61% men •30 teams using Skype and 30 teams using Second Life
Second study	•3D virtual Environments •Non precise task	•Quantitative •144 valid responses have been gathered

	•Non-guided collaboration •Field study	

Table 6 Summary of quantitative studies

Design science

From the design science side, collaboration scenarios are designed basing on theories applied in the context of the game. These scenarios are focusing on the study of collaboration in VWs taking into account the determinants of the research model. Scenarios are designed regarding the relationships between different determinants. They change also regarding control variables and provide team performance scoring. Indeed, during these scenarios, we vary control variables.

Scenarios will be used by participants in laboratory or field studies (quantitative studies of the behavioral science side). Results of these studies will be exploited to enhance and/or review the model. These iterations will be repeated several times.

At the end of the process, two relevant contributions to the literature will be provided if one follows this methodological framework.

- **A theoretical contribution**: a research model analyzing team collaboration in VWs. This artifact will serve to bring understanding about this specific kind of collaboration.

- **A practical contribution**: collaboration scenarios taking into account the specificity of 3D VWs. They will serve to give deep understanding for succeeding collaboration through these virtual environments. Two kinds of scenarios will be considered: leader guiding scenarios and teammate scenarios. They will be specific to each category. An exploratory study has been performed through a first kind of collaboration scenario (design of leader collaboration scenario).

This framework allows a longitudinal study of team collaboration in 3D virtual worlds. Indeed, it permits the evolution of a first research model into more developed and rich one after a quantitative study conducted as a lab experiment or a field study.

Once a collaborative scenario takes into account one determinant, we can vary control variables (age, experience with technology, etc.) of the sample of the participants. The collaborative scenarios will be refined by the set of feedback from these participants. These iterations could be repeated until having a final research model gathering all determinants of team collaboration and its corresponding serious game.

In this research, we have designed two research models and two collaborative scenarios.

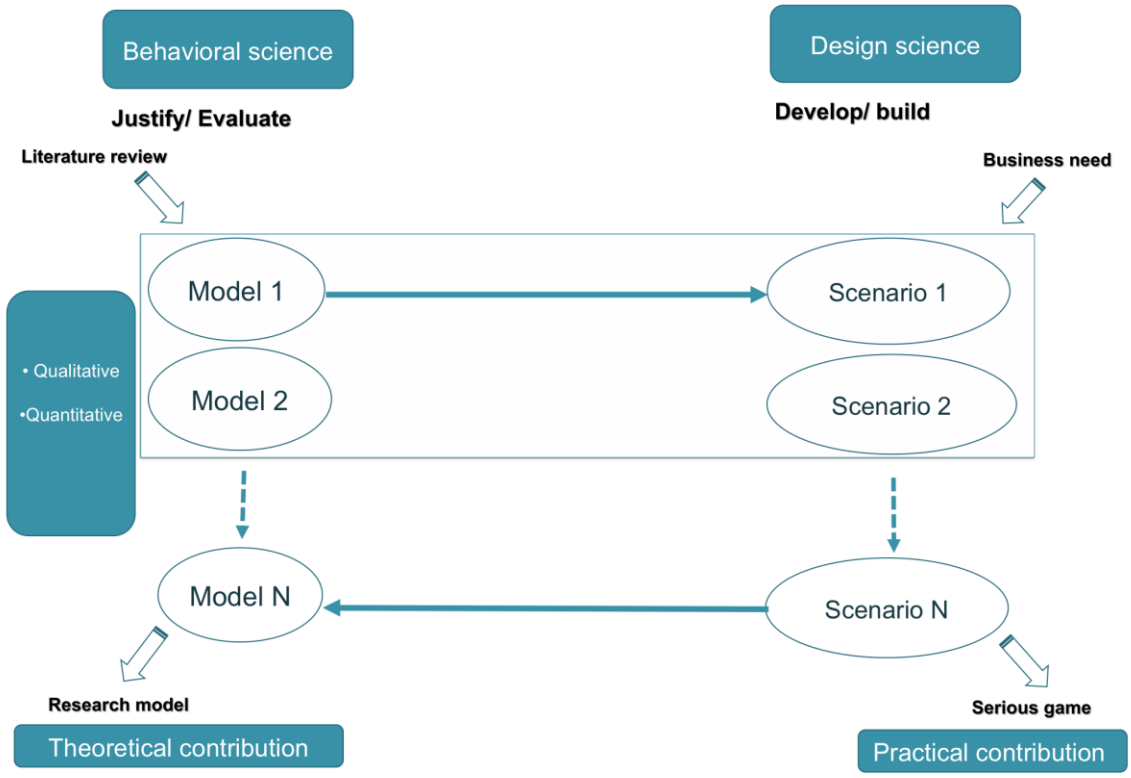


Figure 5 Methodological Framework

3. Conclusion

To address the gap presented in the literature review, we designed two research models containing relevant determinants and describing the relationships between VWs, team collaboration and team performance. A preliminary lab study was conducted to explore collaboration in 3D virtual worlds in order to bring a first experiment. This lab study helped us to identify a set of relevant determinants. This lab study was supported by the literature to refine the list of determinants.

From a methodological point of view, this thesis is based on theoretical framework inspired from the research of Hevner's IS research framework (2004) combining behavioral science and design science. From the behavioral science side, exploratory and confirmatory studies are conducted mixing between qualitative and quantitative methods. From the design science side, we design collaboration scenarios (serious game) based on determinants of team collaboration in 3D virtual worlds aiming to vary collaborative scenarios and deepen the study of collaboration in 3D VWs.

The different steps of this research could be detailed in the following figure.

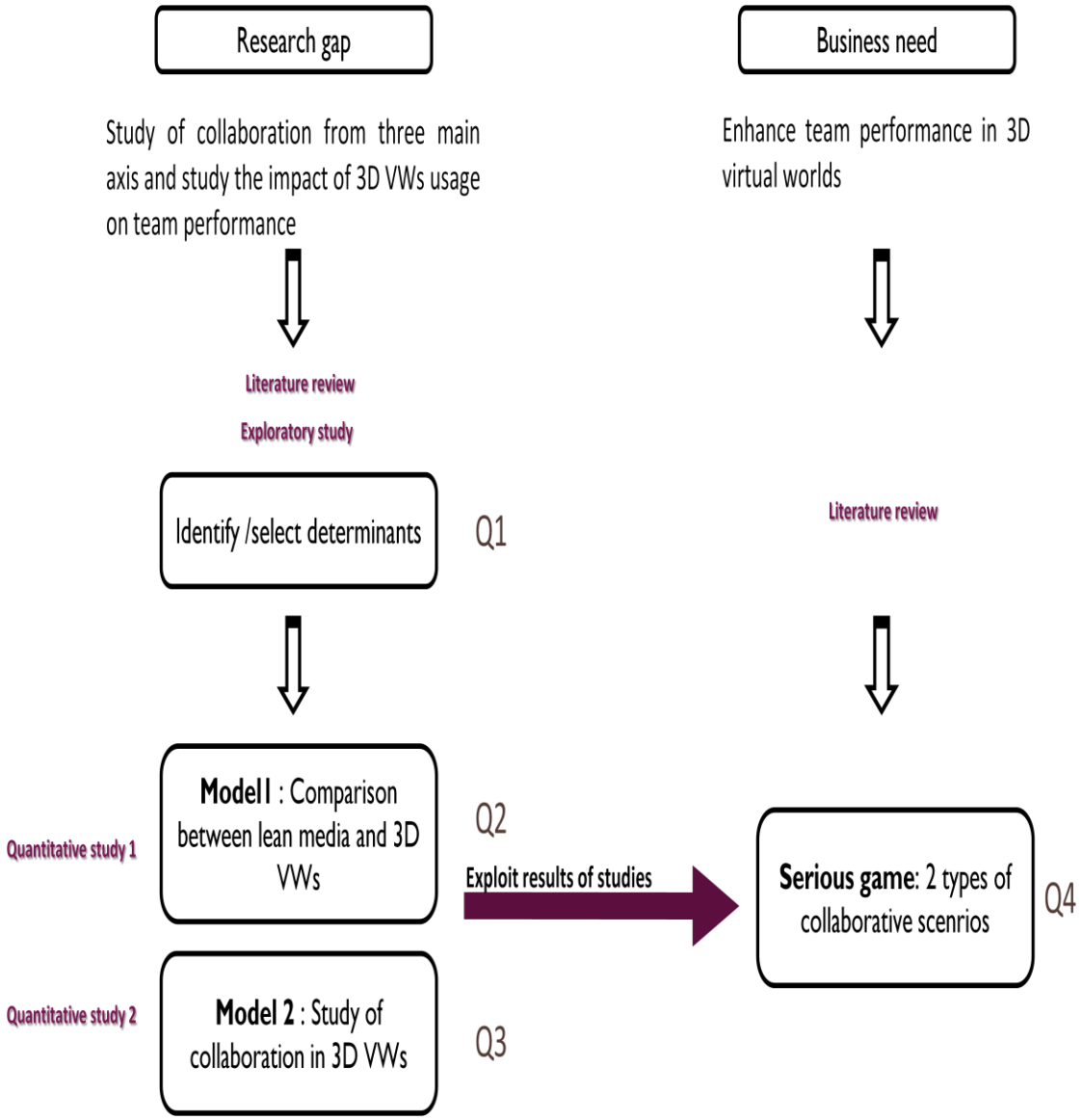


Figure 6 Different research steps

Research in information systems can be of service of management science including the case of this research. In fact, this thesis contributes theoretically and

practically in this field. First, it theoretically provides two research models for the study of collaboration in virtual 3D environments which give managers more confidence on the performance of the team. This may encourage them to integrate this new technology in the aim to take advantage of its assets. As a practical contribution, this research offers them a serious game that will enhance collaboration in these environments. I propose also a list of best practices that can be useful for successful collaboration.

CASE STUDIES AND EXPERIMENTS

CHAPTER V: QUALITATIVE STUDY

"Exploratory research is really like working in a fog. You don't know where you're going. You're just groping. Then people learn about it afterwards and think how straightforward it was."

Francis Crick[29] (1916-2004)

[29] Nobel Prize for Physiology or Medicine in 1962

1. Introduction

Virtual Worlds (VWs) provide many opportunities to overcome some issues of traditional collaboration such as scheduling meetings when team members are working in different countries. But team collaboration in these environments can be more effective but also more challenging to manage.

Both researchers in Management Science—specifically the Information Systems field—and in Computer Science—specifically Computer Supported Cooperative Work (CSCW) and Human Computer Interaction communities —have grown increasingly interested in VWs. Management Science researchers have placed particular focus on studying the emergence and development of virtual organizational settings (e.g., teams, communities, enterprises) (Ahuja and Carley 1999; Armstrong and Hagel 1996; Boughzala 2007; Giddens 1984; Shaw 1971). Such research has focused on the opportunities that VWs, as a form of effective Information and Communication Technology (ICT) provide to enhance business processes. Conversely, computer science researchers have studied the interaction of human beings with VW technology and its capacity to support collaborative work (Bessière 2009; Ducheneaut et al. 2009; Yee 2007). For instance, VWs can influence critical business functions such as internal information sharing, e-commerce, partnerships, organizational learning, value creation, and innovation (Kock 2008). Several researchers have also explored the contribution of VWs as a space for social interaction and a tool to increase, facilitate, and lead team collaboration (Davis et al. 2009). The efficient and effective use of VWs as a platform for team collaboration may yield a variety of benefits to an organization ranging from reducing operating costs (e.g., travel, lost work time due to excessive or untimely meetings), to enhancing productivity (e.g. speed and richness of collaboration, creativity).

Owens and colleagues (2009) argue that VWs can enhance collaboration and VW project management through the unique technology capabilities they provide. That is, when using VW technology capabilities, VW project teams have access to efficient, as well as richer, more engaging environments to help overcome collaboration barriers. However, many organizations are cautious of the unintended consequences of utilizing VW collaboration. Indeed, they consider VWs as surrounded by much hype and uncertainty regarding concrete business value. Several studies highlighted

factors that could negatively impact an organization, such as poor security, and the lack of a clear legal framework and governance

Despite the fact that several research teams have embarked on the study of collaboration in VWs (Davis et al. 2009), there has been limited research into the perceived challenges and opportunities for organizations operating in these environments (Tikkanen et al. 2009). To establish a basic understanding of VW opportunities and weaknesses, many questions need to be answered, including but not limited to: What might be inhibiting or enabling team collaboration in VWs? What might encourage or discourage organizations to invest resources into VWs? What factors optimize the likelihood of successful team collaboration and high quality of outcomes?

To the best of our knowledge, there are few studies that attempted to answer such questions (Davis et al. 2009; Hendaoui et al. 2008; Kock 2008; Owens et al. 2009). Thus, not surprisingly, a taxonomy of salient opportunities and challenges for VW collaboration has not been proposed. As such, we conducted a Delphi study to address this research gap. The Delphi method consisted of an initial brainstorming session, which was followed by a consolidation of key issues and a ranking of these issues. This resulted in a taxonomy of issues relevant to VW collaboration. We then expanded our findings by allowing our panel of experts to openly discuss these issues to ensure the relevance of the initial brainstorming results. Specifically, the current study was exploratory in nature and identified initial barriers and opportunities for VW adoption.

Our findings may help organizations to better prepare their venture into VWs by heightening their awareness of the major challenges of this emergent technology. The relevant issues identified in this study also provide a starting point for better understanding and further researching factors that influence the optimal utilization of VWs to conduct team collaboration. Furthermore, the understanding of several barriers related to the technology will lighten the path to enhance VWs design (Ducheneaut et al. 2009).

The remainder of this chapter is structured as follows. The next section introduces our methodology for identifying the opportunities and challenges associated with

team collaboration in VWs. Next, the results of the study are detailed in the third section. Section 4 discusses our findings and their implications with the support of a complementary qualitative study through an open discussion with participants. The chapter concludes with a summary of the key findings, limitations, and directions for future research.

2. Method

In order to address the aforementioned research gap, we asked our panel of experts to identify challenges and opportunities organizations may face when using VWs in a collaborative context. We conducted a SWOT analysis from a brainstorming session as a preliminary exploratory study with graduate management students. This SWOT analysis is intended to present possible perceived Strengths, Weaknesses, Opportunities, and Threats of team collaboration in VWs. This study addressed two primary types of factors that influence VW collaboration: 1) internal factors including strengths and weaknesses of VWs, 2) external factors including opportunities and threats. The SWOT analysis generated an organized set of factors which may help organizations to deepen their understanding of the costs and benefits of using VWs for team collaboration. These factors can help inform companies of the advantages to working in VWs, as well as raise their awareness of the prospective threats inherent to VWs. To address these SWOT analysis categories, we considered the following questions:

- Strengths: What factors do you consider as major advantages of VWs?
- Weaknesses: What factors do you consider as major drawbacks of VWs?
- Opportunities: What potential opportunities do VWs offer in a collaborative context?
- Threats: What potential threats do VWs pose in a collaborative context?

To conduct our exploratory study, we used a Delphi approach. Delphi studies are regularly used in information systems studies when a consensus needs to be achieved among domain experts on a topic where ideas generation is required (Keil et al. 2002). We enriched the Delphi process through a thinkLets-based (Briggs et al. 2003) facilitation process. ThinkLets are codified best facilitation practices that create predictable, repeatable patterns of collaboration among people working toward a goal.

They are used to streamline collaboration during brainstorming sessions, rapid decision-making, evaluation of strategic objectives, team building, and creativity (Vreede et al. 2009).

While Delphi studies are normally survey-based (Schmidt et al. 2001), we had the opportunity to use a Group Support System (GSS – here a customized Sphinx Web Reporting application) and a well-structured facilitation process. A GSS is a suite of software tools designed to support collective problem solving, including the generation of ideas, reducing, organizing, and evaluating idea sets (Fjermestad and Hiltz 1999). These tools facilitate the emergence and sharing of information among participants, and assist the facilitators in the control of the participants' reflection process. Each participant in a GSS session uses a computer to submit ideas and votes to the group, to make selections, to organize ideas, or to write draft texts. Using a GSS, all team members can contribute simultaneously, and may generate and evaluate ideas anonymously, while participating in well-structured deliberation processes (Dennis et al. 2001). The use of a GSS allowed us to collect in a bottom up fashion, extensive and well-organized group collaboration results. It also served for the development of a synthesis report summarizing the results of the process, which was presented and discussed with all participants.

The Participants

In March 2011, students of a 3D VWs course were invited to participate in a study at the authors' institution. They were asked to do a SWOT analysis of VW collaboration using electronic brainstorming. Demographics of the study participants are provided in Table 7.

Study data
• Total Participants: 13 • All participants are Management Graduate students • Youngest Participant in Age: 21 • Oldest Participant in Age: 26 • Male Participants: 6 • Female Participants: 7 • Web 2.0 and VWs Experience: Very Often

Table 7 Delphi study participant demographic data

The Brainstorming Process

The brainstorming process consisted of several activities in which the participants were asked to engage during a 180 minutes period. A summarized agenda and research process follows:

- After an introductory presentation on VWs and the scope of the meeting, participants were asked to anonymously generate ideas around the four SWOT themes.

- Participants were then assigned to four subgroups and asked to reduce, clarify and organize collectively generated ideas into unique statements around one of the four themes. Each subgroup was assisted in this task by a facilitator. The goal was to converge on similar ideas, remove non-related ones, and reword those insufficiently clear.

- Participants then rejoined as a single group. Each subgroup facilitator presented and explained to the group which statements were selected for their respective theme.

- Participants were then asked to individually and anonymously rate the relevance of each statement on a 10-point Likert-type scale, with '10' representing a very relevant statement and '1' a least relevant statement relating to each of the four SWOT themes.

- The voting scores were then presented to all participants in a raw format to stimulate a discussion of the results (proposal by proposal), and to allow the reformulation of proposals when necessary, to clarify ratings' standard deviations and so to build a collective consensus.

Finally, we conducted an open discussion for 90 minutes with the same participants about the brainstorming results. We aimed to deepen and clarify their understandings of the statements' importance and their role to make teamwork in VWs successful. A list of guiding questions addressing these constructs was prepared to facilitate the discussion.

3. Results

The SWOT analysis produced a total of 146 ideas during the initial brainstorming activity aiming to identify opportunities and challenges of VWs. These ideas were reviewed, reclassified, and paraphrased following the process described in the previous section. We reduced them to 32 statements (9 strengths, 7 weaknesses, 9 opportunities, and 7 threats). After data collection, we reviewed and paraphrased the overall results from the SWOT analysis category lists to enhance clarity. Some key questions were asked about the collected data to ensure ideas were appropriately classified and represented:

- Are the resulting statements possibly misclassified between threats and weaknesses or between opportunities and strengths?
- Are the resulting statements appropriate and within the scope of team collaboration?
- Are the resulting statements specific to a particular VW?

After careful consideration, we organized and put the results in four tables, tables 6 through 9. (SD = Standard Deviation).

Strengths	**Mean**	**SD**
Universal access	8	1.89
Entertainment	8	2.07
Simulation (object manipulation)	7	1.79
Environment personalization and flexibility	7	1.65
Shaping personality	6	2.78
Pleasant working environment	6	3.17
Cost reducing	6	2.25
Saving energy	6	3.01
Socialization	4	2.36

Table 8 Strengths: Strengths consolidated from an initial set of 49 ideas and then reviewed, reclassified, and paraphrased.

As a result of the brainstorming activity, participants identified some relevant strength. First, participants highlighted the universal access to VWs from everywhere and for everyone. This virtual trait is inherited from the Internet and helps to eliminate boundaries and reduces communications' constraints. Secondly, they identified the

entertaining environment which may help to make work condition more pleasant. Additionally, they cited the possibility to simulate processes remotely which is more realistic compared to other collaborative environments (i.e. Groupware) where visualization (Hall et al. 2008) and or co-presence (Schroeder 2006) are not possible.

Third, they stressed the possibility to personalize the environment and make it better suited to users' demands. In a participant's words "*environment personalization helps to define a suitable environment which improves performance*". Furthermore, the possibility to personalize the avatar seemed to be relevant. Said one participant "*Personalization allows us to be identified with our own profile",* i.e. to be different from others. So one could be "*identified with his/her character"* or *"getting a desirable image"*, and "*shape his/her personality as desired*". These findings regarding personalization reflect propositions of Ducheneaut and colleagues (2009). Furthermore, users can overcome shyness and interact with people without constraints. Consequently, VWs increase socialization by facilitating the "*connecting with new people"*, and because "*communications are easier and so socialization becomes easier*". Finally, participants declared that VWs help to reduce transportation and accommodations costs. Indeed, like other means of electronic communication, VWs save travel expenses and reduce traffic pollution.

Weaknesses	**Mean**	**SD**
Impersonal social communication (desocialization)	9	1.26
Lack of juridical framework	9	1.12
Hacking and fraud	8	1.93
Requiring advanced technical skills	8	1.82
High hidden cost	7	1.76
Loss of touch with reality	7	2.81
Requiring many technical resources	6	2.31

Table 9 Weaknesses: Weaknesses consolidated from an initial set of 48 ideas and then reviewed, reclassified, and paraphrased.

According to the participants, many weaknesses seem to pervade VW collaboration. First, VWs may lead to impersonal social communication. So people will lose important aspects of human contact (desocialization) and "*loss of touch with reality*". That is, VW participant contacts may become virtual contacts only. Moreover, participants are wondering about conflict management in VWs with a lack

of juridical framework. One participant said: "*Possibility of conflicts in 3D life, which rules could one apply?"*. Some weaknesses are specific to VWs' technology such as security problems namely hacking and fraud in absence of legislation associated with conflicts in VWs. Furthermore, VWs require advanced technical skills and high hidden cost as well (e.g., subscription fee, software cost). Finally, the use of such technology requires many technical resources such as an advanced graphical card and a powerful processor.

Opportunities	**Mean**	**SD**
Distance reducing	9	1.40
Real time and rapid communication	9	1.44
Time saving	8	1.23
Less discrimination when the visual identity is hidden	8	1.61
Free opinion expression	8	2.36
Personal skills development	6	1.89
Risk reducing with process simulation	5	2.54
Increasing creativity	5	2.86
Easy knowledge sharing	5	2.81

Table 10 Opportunities: Opportunities consolidated from an initial set of 30 ideas and then reviewed, reclassified, and paraphrased.

The participants identified many relevant opportunities that may help us to better understand team collaboration in these new environments. First, participants argue that VWs allow people to work remotely from any place—such as their homes. Exchanges between team members may become faster thanks to real time and rapid communication. Consequently, this may "*accelerate project development*" and allow time saving. Second, users are able to hide their visual identity and, in the same time, other team members could know the statue, the identity and competencies of the persons with the hidden visual identity. This may reduce discrimination (e.g., disability, gender, race…) and "*makes discussion in team richer because there is no judgment*". This "*ensures to everybody to express him/herself more easily and freely*". So one may overcome his/her shyness and participate positively in team discussions. Moreover, people can use VWs to develop new skills such as learning languages, attending conferences, and doing process and object simulation. Third, one may reduce project failure risks thanks to remote simulation and a rich tool environment. Furthermore, participants argue that these environments could help to increase

creativity through cross-organizational and cross-cultural collaboration. Finally, VWs make knowledge sharing much easier which is relevant and "*enriching to team collaboration*".

Threats	Mean	SD
Identity theft and hacking	9	0.96
Reduced efficiency	9	1.55
Social loafing	9	1.55
Psychological issues	9	1.19
Perception issues	8	2.2
High dependency on machine reliability	8	1.82
Leadership issues	7	2.33

Table 11 Threats: Threats consolidated from an initial set of 19 ideas and then reviewed, reclassified, and paraphrased.

The last stage of the brainstorming activity was related to threats of VWs when people work in teams. The findings in this section align with the literature review (Cahalane et al. 2010). In fact, safety issues are strongly highlighted by the majority of participants (means are high and SD are low). They identified some relevant threats such as identity theft, hacking and use of invisible avatars. They also focused on the impact of the use of VWs on team efficacy. They argued that team efficacy may strongly decrease due to the lack of emotion and gesture. Thus, it may be difficult to explain ideas and read body language in VWs, which may lead to more misunderstandings and lower team efficacy. Moreover, the risk of social loafing seems to be noteworthy with the possibility to hide one's visual identity in these environments. That is, social loafing is hard to regulate in this context. One participant said "*no one could know what people do in virtual meetings, are they concentrated, do they listen…"* Another one said, "*People may feel lack of commitment when there is no supervision*". Another one declared that "*social loafing may increase when there is no supervision in team work*" According to the participants' contributions, hiding the visual identity could complicate some leadership issues because it is hard to manage a VT mainly when we do not know or see members. Indeed, when we do not know or see the leader we will not be able to feel his/her charisma and influence. One participant declared that an "*unknown person could not have so strong influence on people*". Another said "*human contact is indispensable for creating leadership in a team*". Furthermore, VWs may lead to some psychological issues such as dependency on these worlds, and social isolation in the physical world. As such, VW participation may have a harmful impact on persons,

families and society. Finally, participants highlighted the strong dependency on a machine that may not be always reliable. Indeed, some connection troubles or electricity issues "*could lead us to stop working or cancel a meeting*".

Construct	Definition	Reference
Knowledge sharing	Attitude involving beliefs, feelings, values and dispositions to share particular knowledge with particular people (Boughzala and Briggs, 2011).	(Cramton 2001)
Object manipulation	Reach out a hand, grab an object (using a button or a gesture), and move it around the virtual environment (VE) using natural, physical motions.	(Robinett and Holloway, 1992)
Social loafing	The reduction in motivation and effort when individuals work collectively compared with when they work individually or coactively	(Karau and Williams 1993)
Socialization	The means by which social and cultural continuity are attained.	(Clausen, 1968)
Leadership	Process of social influence in which one person can enlist the aid and support of others in the accomplishment of a common task	(Chemers 1997)
Personalization	Customizing and changing the appearance of the avatar or the environment around the avatar.	(Ducheneaut et al, 2009)

Table 12 Key findings: Definitions of the constructs from the literature.

Discussing the strengths, weaknesses, opportunities, and threats of VWs during the brainstorming activity yielded results that appeared to relate to factors are arguably relevant for team collaboration in VWs, such as personalization (Ducheneaut et al. 2009), social loafing (Karau and Williams 1993), hiding visual identity, object manipulation and simulation (Robinett and Holloway 1992), knowledge sharing (Cramton 2001), socialization (Clausen 1968) and leadership (Chemers 1997) These are factors which distinctly influence team collaboration. They are neither opportunities nor threats but fundamental constructs that impact team collaboration. Some of them may enhance team collaboration such as knowledge sharing while others may inhibit collaboration in VWs such as social loafing. To further enrich our understanding of the participants' perceptions on these constructs and their role in team work in VWs, we conducted an open discussion focused on enablers or inhibitors of VW collaboration. To this end, a list of open-ended questions was

prepared that were used to guide the discussion. These questions and a summary of the participants' responses are presented below.

1. **Does it make any difference when you personalize your profile (avatar, space, decor...)?**

Participants suggested that personalizing their profiles, including but not limited to their avatars, spaces, and décor, influenced their collaboration experiences in VWs. First and foremost, they indicated that profile personalization helped establish an identity in the VW. Having a unique identity reflected in a personalized profile puts users at ease in a VW because it "*gives you a style, makes you original and helps you feel closer to your avatar and at ease with the environment.*" In fact participants reported that individualizing a VW profile is just as important maintaining a desirable personal image in real life, and some respondents went as far as to suggest that a personalized profile "*is a window to our personality."* Furthermore, this process of establishing an identity helps users "*interact with others*" by creating a desirable image of a character that fellow users can perceive as a unique person. Participants indicated that being able to customize one's image in a VW can be particularly beneficial because users can control the appropriateness, attractiveness, and aesthetic value of how they appear to others.

2. **To what extent would it make a difference when manipulating object in these VWs?**

Participants also expanded on how the capability to manipulate objects in VWs influences team collaboration. They explained that object manipulation "*makes us feel closer to reality"* because it gives the perception of touching and interacting with the environment. In addition to making users feel more comfortable in an enriched environment, object manipulation improves collaboration by making idea sharing "*more interactive and illustrative.*" For instance, being able to visualize and ask questions about a project "*decreases project failure risks when processes can be simulated"* for all team members to understand. Moreover, object manipulation is expected to enhance learning in VWs because this function allows users to view a modeled behavior and then practice it.

3. **Does it make a difference to hide your visual identity when collaborating with others?**

Further probing of the SWOT analysis indicated that the contributions of participants with a hidden visual identity could have a variety of impacts on VW collaborative efforts. Interestingly, about half of the participants heralded the benefits of this kind of participation, whereas the other half suggested that it could be detrimental to collaboration. Those in favor of being able to hide their identity indicated that it "*makes communication easier"* because it reduces evaluation apprehension, and provides "*more freedom to express your opinion."* Proponents of this method also reported that it increases the richness of debates because judgments focus on the idea rather than the person. Conversely, the other half of the participants warned that visual anonymity makes collaboration "*less comfortable"* and "*feel more distant."* An argument was made that hidden visual identity decreases spontaneity in that participants are less likely to engage in a rich dialogue. Importantly, it can lead to distrust when participants cannot make judges of credibility, and in some cases this lack of credibility can "*encourage people to be less serious"* about the issue at hand.

4. **To what extent you think that hiding your visual identity could increase social loafing?**

Moreover, the participants elaborated on how hidden visual identity can increase social loafing. The most common issue that participants identified was that it makes virtual collaboration more crucial. Indeed, it will be more difficult to supervise team members because they can hide behind their computers and nobody knows if they are not contributing to a discussion. The nature of this communication may not be conducive to encouraging participation because those not already committed to the task at hand "*can be more lazy* (by not contributing)," and do not have to worry about defending their reputation. Thus, social loafing is likely to occur unless team members are invested in the goal of a collaborative effort.

5. **To what extent you think that hiding your visual identity could influence leadership?**

Leadership is critical to effective collaboration and participants explained that hidden visual identity in collaboration can both help and hinder the influence of

leadership in VWs. On one hand, it can facilitate leadership because "*Shy people can express themselves more easily and become leaders in the VW.*" it may also encourage the group to share leadership responsibilities. On the other hand, hidden visual identity can be detrimental to leadership efforts when it deteriorates the interpersonal relationship between leaders and followers. For example, if "*everyone considers him/herself equal to the other group members, everybody may want to lead the team and nobody would want to take instructions."* In this instance, it would make it difficult for the assigned leader to leverage his authority and regulate the group. Further, trust between leaders and followers, is essential to effective collaboration; therefore, hidden visual identity is likely to breed distrust when followers cannot become intimately familiar with their leader. The absence of face-to-face interaction makes trust very difficult to build, especially for newly formed teams.

6. **To what extent do you think that socialization could enhance knowledge sharing?**

Finally, participants indicated that socialization during VW collaboration efforts could enhance knowledge sharing by means of building bonds and trust that in turn increase the willingness to share and collaborate. Socialization may even lead to collaboration and knowledge sharing outside of the structured collaboration session if people discover they share a common interest. Participants did echo some concerns that socialization in VWs can be a distraction when it takes the focus of collaboration away from accomplishing the task at hand. However, they suggested that socialization is more likely to stir mutual interests and inspire new ideas than it is to overwhelm collaborators with distractions.

4. Discussion and conclusions

VWs are pervading our daily life and are working their way into our offices. They seem to be an object of diverse opinions, criticisms and support, ranging from the fear of losing human contact to the considerable advantages of distributed team collaboration. From a logistics standpoint, VWs inherited some advantages and opportunities from VTs. For instance, VWs are relatively cheap and easy for anyone to access remotely from everywhere at anytime, they can reduce distances and costs, save time and travel efforts. They allow real time and rapid communications. These

findings align with Owens and colleagues (2009) and Davis and colleagues (2009) research. Further, from an interpersonal standpoint, VWs allow an easy knowledge sharing which is one of the bases of virtual team collaboration according to Cramton (2001).

Moreover, VWs have several advantages and opportunities related to the technology. For instance, VWs are customizable environments and have a gaming aspect. As such people will feel more comfortable when working in a pleasant and flexible environment that they can control. Avatar personalization is important because it allows users to express their personality and utilize an avatar to they can relate to. This finding matches with Ducheneaut and colleagues (2009) research as they found that people were more engaged during VW activities when their avatar reflected users' persona. Moreover, the ability to create and manipulate objects in VWs offers the possibility to reduce risks through process simulations, increase the creativity of users, and help users to develop their interpersonal skills. In addition, VWs provide the possibility to hide one's visual identity which may decrease discrimination among team members and allow them to express their opinions more freely. Finally, VWs facilitate more realistic socialization than experienced by traditional VTS, which matches Hendaoui and colleagues' (2008) conclusions.

Basing on these findings, the adoption of VWs into our daily lives and organizations is expected to increase in the future in the age of Web x.0. However many threats or issues remain unresolved. These obstacles could have some negative effects on the adoption and acceptance of VWs by teams due to salient drawbacks and threats. In fact, VWs' lack a juridical framework and provide poor security against hacking, fraud and identity theft as seen in the research of Lastowka and Hunter (2004 ;2005). In addition, several leadership problems have been reported—mainly due to the lack of face-to-face and body language communication. Consequently, team efficiency could drop significantly in VWs. In addition, VWs require advanced technical skills which may inhibit users from adopting them (Bessière et al. 2009). Finally, VWs could lead to some psychological issues such as isolation, addiction, social loafing and loss of touch with the reality.

After data analysis, we noticed a set of constructs that seem to be relevant to effective collaboration in VWs. They are factors may positively or negatively

influence team collaboration in VWs, such as social loafing, knowledge sharing, socialization etc. Some of these factors are essential to effective collaboration, and all have an obvious impact by enabling or inhibiting individuals or teams when collaborating. Enabling factors include opportunities such as knowledge sharing, and others are inhibitors such as social loafing. Some factors can even be both enablers and inhibitors such as the use of hidden visual identity. These understandings/insights are a first step towards an optimal utilization of VWs to conduct team collaboration and help for better designing of future VWs.

This study is a preliminary exploratory study on the salient barriers and opportunities of collaboration in VWs. It reported the point of view of management students (from the digital generation) on the adoption and use of VWs for team collaboration. The participants produced a list of ideas about their perceptions of teamwork in VWs. The results provide interesting insights on the various opportunities and challenges organizations face when managing distributed teams in VWs. Nevertheless, this study has several limitations to be taken into account. First of all, it was conducted with a limited number of students from the same class. Second, all participants came from the same geographic location which could lead to a regional bias. Finally, students involved in this study did not actually perform collaborative work tasks for their job in VWs. However they do belong to the digital generation, which tends to be adept at using many Web 2.0 technologies. Further, they are graduate management students who are very sensitive to virtual project management. To address these limitations and as future research directions, we plan to conduct a field study involving experts and managers already using VWs for collaboration.

This exploratory study is an early step in a research program. In the next chapters, we will enrich this list of team collaboration factors by conducting two quantitative studies examining the relationship between team collaboration factors and performance. It is our hope that this research will address and spawn further research questions surrounding organizations' use of VW. We also hope that this study will aid organizations in deciding they can successfully leverage team collaboration in VWs.

This study brought relevant role to identify a set of important constructs that could potentially impact team collaboration. This study helped as to identify new

determinants. Now, we have to select which are determinants that are relevant to be studied in this thesis. However, in this thesis we will not study leadership and socialization which have been more remarked in game type VWs such as WoW. In the aim to process the selection, we set four main criterion of selection and each determinant must fulfill two criterion to be selected and studied later. The following table presents the determinants that were selected and the set of all criteria.

Selection criterion Determinant	Specific to 3D virtual worlds	Strong impact on 3D virtual worlds	Not studied in 3D virtual worlds	Important impact on collaboration in Virtual teams and face-to-face setting
Knowledge sharing			**X**	**X**
Customization	**X**		**X**	
Knowledge application			**X**	
Object manipulation	**X**		**X**	
Technology usage			**X**	**X**
Density			**X**	**X**
Co-presence		**X**	**X**	
Cognitive absorption		**X**	**X**	
Social loafing			**X**	**X**

Table 13 Criteria of determinants' selection

In the next study our focus will be more centered on the study of IT inner dynamics that differentiate VWs from other technologies such as Skype. What are the determinants that will be on the focus of this study ?

CHAPTER VI: FIRST QUANTITATIVE STUDY

"Never regard study as a duty, but as the enviable opportunity to learn to know the liberating influence of beauty in the realm of the spirit for your own personal joy and to the profit of the community to which your later work belongs."

Albert Einstein [30] (1879-1955)

[30] German-born theoretical physicist who developed the general theory of relativity, he got the Nobel Prize in physics in 1921

1. Introduction

Collaboration technologies are allowing organizations to leverage their global workforce (Robert 2013). Modern organizations are facing economic forces and global competitive pressures that require them to innovate in order to maintain and enhance their performance (Wang and Haggerty 2009). In these complex and dynamic global environments, organizations must deploy and redeploy their resources to address these dynamic challenges. The most important organizational resource is often the expertise of their employees (Robert et al. 2008).Unfortunately the employees with needed expertise are often not collocated and organizations must assemble teams with dispersed members (Jarvenpaa and Leidner 1999; Robert et al. 2009). Organizations meet these challenges using teams that rely on collaboration technologies to communicate and coordinate their activities.

Indeed, teamwork is being increasingly influenced by the set of technologies involved in the work place (Martins et al. 2004). Teams whose members are geographic dispersed and rely on collaboration technologies as their primary form of communications are often referred to as Virtual Teams (VT) (Dennis et al. 2012b; Jarvenpaa and Leidner 1999; Robert 2013). These VT use different technologies for communications, knowledge sharing, decision-making, etc (Robert et al. 2008). These technologies are provided to make teams more effective by facilitating teamwork (Griffith et al. 2003). Indeed, technology provides a means to structure teamwork and facilitate information retrieval and communications.

This means understanding the effectives of technologies use on teamwork is an important area of research. This area of research becomes increasingly important because organizations are providing their teams with new types of technology. The importance of this work is highlighted by the vast body of research on the topic. For example, several researches have focused on VT such as (Agarwal and Karahanna 2000; Ahuja and Carley 1999; Daft and Lengel 1984; Dennis and Kinney 1998; DeSanctis and Monge 1999; Gassmann and Zedtwitz 1999; Martins et al. 2004; Robert et al. 2009; Short et al. 1976; Townsend et al. 1998)). Several VTs' attributes and inputs that impact team performance have been studied such as team size (Leenders et al. 2003; Steiner 1972); knowledge (Bock et al. 2005); technical expertise (Kayworth and Leidner 2000); technology (media richness (Daft and

Lengel, 1984) and media synchronicity (Dennis et al 2008), cognitive absorption (Agarwal and Karahanna 2000). Yet little work has been done to understand how media differs in its ability to facilitated cognitive absorption.

While this research topic is relevant other areas had received less attention. For example, much less is known about the effects of cognitive absorption and virtual co-presence on team performance or how different technologies facilitate or inhibit their development. Indeed, little is known about the mediating effects of these constructs across different technologies. Specifically, few studies have examined the effects of new technologies like 3D virtual environments (e.g. Second Life). How do these 3D virtual environments impact team performance? And do they do so differently than their traditional counterparts? And what are the mediating processes that differentiate the impact of these technologies?

This study is an attempt to begin to answer these research questions by bringing new insights from various theories. The study presents the results of a test of the effects of Skype and Second Life on virtual co-presence, cognitive absorption and ultimately team performance. We find that the use of each of these technologies leads to significant differences.

This study puts forth a research model that proposes that teams that use Second Life should have higher levels of cognitive absorption, virtual co-presence, team communication density and team performance than teams that use Skype. Results of the study generally support the research model. This study contributes to our understanding of how virtual worlds increase the performance of virtual teams.

2. Second Life vs. Skype

Second Life is the best-known 3D virtual world; it is a cognitively engaging technology (Chandra et al. 2012) where users interact via avatars. It provides high synchronicity in communications, a 3D representation of avatars affording a sense of presence and immersion (Animesh et al. 2011; Biocca et al. 2003). In addition, it provides hand gestures and facial expressions and movements allowing rich interactivity between avatars (Davis et al. 2009; Franceschi et al. 2009; Suh and Lee 2005). According to Franceschi and colleagues (2009), virtual worlds are unlike videoconferencing (e.g. Skype), because they provide a shared visual space for user

where they meet and interact via their avatars. Users are sharing the quasi-realism of the 3D environment, they can see each other's avatars, and they can hear each other. In addition, they can manipulate artifact together. According to authors, these factors are giving 3D virtual Worlds strong sense of group presence, which will lead to more engaging group interactions.

Skype provides voice and video communications. People are able to start video-conferences and see each other. However, the communication becomes annoying as soon as the number of participants increases. Consequently, the number of ties within network (notion of density) will drop, as the management of the amount of information that can be transferred between individuals will be hard in this context.

Given the above-mentioned aspects of contemporary organizational teams, technology capabilities for communication and coordination may be important determinants of enhanced performance. However, due to the growth of technologies there is a huge surge in the different technologies that are now used for teamwork. The dynamics in these technologies, however, are quite different due to the difference in how they may influence (enhance or inhibit) individual behaviors. According to the organizational behavior literature, team member performance is determined by various behavioral processes (Bourgeois 1980). However it is important to identify how these behavioral processes influence performance, and whether their impacts differ across different technologies. Knowledge of these effects is critical for firms to effectively leverage their IT portfolio.

3. The research model

In this study, we propose that teams that use Second Life will outperform teams that use video based Skype. We farther posit that the performance differences will be due to the increases in virtual co-presence, cognitive absorption and density of team interactions.

Cognitive absorption

Cognitive absorption is a state of deep involvement in interaction (Agarwal and Karahanna 2000). This concept has its roots in psychology and is described by three conceptually similar constructs namely concepts of absorption (Tellegen and

Atkinson 1974), the state of flow (Csikszentmihalyi 1990), and cognitive engagement (Webster and Ho 1997). This construct contains five main dimensions: Temporal Disassociation, Heightened Enjoyment, Focused Immersion, Control and Curiosity. Temporal dissociation is marked by the inability of the user to register the passage of time when engaged in the interaction. Focused immersion is a state of complete engagement with the task independently of distractions around the user. Heightened enjoyment is the state of pleasure and enjoyment users felt when performing the interaction. Control refers to the sense of being in charge of the interaction. Finally, curiosity refers to the aroused sensory and cognitive curiosity that users get from the interaction. Burton-Jones and Straub (2006) considered cognitive absorption as a way to measure a user's engagement with an information system during use. As it marks a state of deep involvement and engagement with a task, greater cognitive absorption may enhance individual interest and application to the task. Cognitive absorption has found to be a key driver to the adaptative intention to use Virtual Worlds for workplace collaboration (Chandra et al. 2012). Furthermore, it has been found to enhance team performance (Burton-Jones and Straub 2006).

Hypothesis 1: Greater Cognitive Absorption has a positive influence on Team Performance.

Density

Density describes the overall level of interaction between team members (Robert et al. 2008). When group members interact with a larger (rather than smaller) proportion of team members, the team should benefit in terms of "greater cooperation, greater information sharing, a stronger sense of accountability, greater agreement on expectations, and less tendency to engage in social loafing" (Sparrowe et al. 2001). Often the number of interaction ties available between individuals is called a network's potential density. The number of ties within a network determines the potential amount of information that can be transferred between individuals. Intensity is the degree to which teams utilize these ties to interact. In essence, the intensity of the network represents the degree to which the team members socially interact. One of the earliest studies of the impacts of internal team density is (Lucius and Karl Kuhnert 1999). This study examined 29 teams at a military college and found that team density was positively related to team satisfaction and team performance. Sparrowe et al.

(2001) studied field teams involving 190 employees in 39 work groups. They examined impact of social networks positive and negative on both the individuals and group performance. The result indicated that the hindrance network density was significant and negatively related to group performance. Research and Development teams were examined and network density was found to impact team performance (Reagans and Zuckerman 2001). Balkindi and Harrsion (2006) conducted a meta-analysis involving 37 studies of teams in field settings (Balkundi and Harrison 2006). Social interactions among team members have been found to be directly related to performance in knowledge integration tasks (Baldwin et al. 1997; Collins and Clark 2003). The meta-analysis revealed that network density impacted team performance, whether it was task related or social related ties. In particular, non-worked related ties had a larger impact of team viability. Reagans and Zuckeman (2001) studied 224 corporate R and D teams and determine that both network density and network heterogeneity both impacted team performance. Collins and Clark (2003) conducted a study of the internal and external networks of 73 top management teams in high technology firms. The study found that the size of their internal networks impacted their firm's sale growth. And their internal tie range impacted their firm's stock return.

Hypothesis 2: There will be more network interaction for teams using voice communication technologies (e.g. Skype) as compared with the teams using Virtual Worlds (e.g. Second Life).

We contend that cognitive absorption is the mediating influence in virtual environments that might lead to greater or lesser impacts of team performance. That is, group interactions will lead to greater team performance if they lead to greater team cognitive absorption in the task. This is because social interactions are the mechanisms by which teams exchange information to successfully integrate knowledge (Patrashkova-Volzdoska et al. 2003). When greater interactions enhance cognitive absorption among team members the more likely they are to exchange task related information. Low level of group interactions might be essential to create such cognitive absorption, however at higher levels increasing group interactions might have a negative influence on cognitive absorption. This is because of the greater increase of information, or the lack of relevance of exchange information in the

interactions. Thus, we contend that virtual environments will have an inverse relationship of group interactions to the cognitive absorption of team.

Hypothesis 3: Network interactions positively influence cognitive absorption initially, but larger network interactions amongst team members have a negative influence on cognitive absorption.

Virtual Co-presence

The growth of virtual technologies to facilitate human interactions has challenged researchers to think about the human presence vis-à-vis the work context. Indeed vast research done across various theoretical streams, such as media richness theory (Daft and Lengel 1984; Daft and Lengel 1986; Trevino et al. 1990), social context cues theory (Sproull and Kiesler 1986), and social presence theory (Short et al. 1976) suggest that media differ in their communication characteristics based on the bandwidth or the number of cue systems available within them. These differences in characteristics often lead to differences in dynamics in the group work, and various concepts have been proposed to conceptualize the individual and group reactions in the virtual environments. The key concepts in this domain include presence, co-presence, social presence, and have been approached from different perspectives. For example, presence may be defined as the "sense of being there", and co-presence as the "sense of being there together"; however there are other subtle variations in definitions across studies (Schroeder 2006). A related concept is that of social presence is defined differently across various studies, and one definition suggests social presence to be the "degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships" (p. 65, Short et al. 1976). In this research, based on the definitions by Biocca et al. (2003), we define co-presence in virtual environments as the extent to which team members are aware of the presence of others while using a communication technology.

While these concepts have been proposed to better understand the dynamics of virtual interactions and technology mediated communications, there is less clarity in definitions or relations amongst these constructs. This has led to a large number of similar conceptualizations such as tele-presence (Biocca 1997), corporeal tele-co-presence, virtual tele-co-presence For example, while co-presence is considered to be

an aspect of social presence others have defined it as an antecedent (Swinth and Blascovich 2001). Further, most prior research has focused on the sense of human to be related to an aspect of technology. Thus, large attention has been paid to examining the extent to which a medium is perceived as truly conveying the presence of the communicating participants (Pavlou et al. 2007). For example, social presence has been conceptualized as "a characteristic of the medium" (Gefen and Straub 2003).

A sense of virtual co-presence may influence the nature of involvement of team members in the task. Specifically, we propose that being distant gives a team its own workspace, and helps members achieve a greater cognitive absorption in the task. However, being physically distant may also create a need for greater group interactions to determine details of group members views, ideas etc. Thus, for a team greater co-presence may be beneficial because of its ability to facilitate cognitive absorption. These dynamics are a focus in the first mediating pathway defines as the Cognitive Absorption (CA) Effect. Cognitive Absorption (CA) effect examines the influence of co-presence on the extent of a team's cognitive absorption.

While technologies impacts on creation sense of presence have been postulated before, in this research, we focus on the performance impacts of the sense of co-presence. Thus given our focus on the performance impacts we do not focus on the characteristics of the media and how they influence the creation of presence. Instead, our focus in this research is on the mediating behavioral factors cognitive absorption and group interactions in the context of teamwork and how they influence overall team performance.

Hypothesis 4: There will be greater perception of Virtual Co-Presence for teams using Virtual Worlds (e.g. Second Life) as compared with the teams using voice communication technologies (e.g. Skype).

Hypothesis 5: Greater perceptions of Virtual Co-Presence will enhance the Cognitive Absorption of team members.

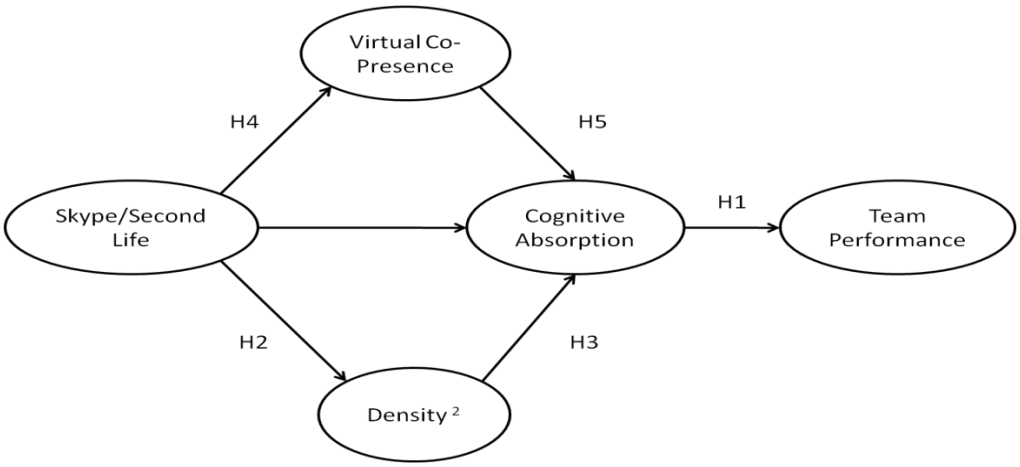


Figure 7 The research model

In order to test the hypotheses we examine how the research model fits with the data collected in the usage of two different collaboration technologies. We presume that individual's cognitive absorption, (i.e. their curiosity, control, enjoyment, temporal dissociation, and immersion), Co-presence and density would be affected differently across technologies with different characteristics and that offer various communication options. The models is tested through data collection in a field experiment setting where virtual teams collaborating via Skype and Second Life were asked to run a SWOT analysis for an unknown company.

4. Data collection Method

The laboratory experiment was set in France. Data collection was made right after the experiment.

Participants

The experiment has been conducted with students recruited from French universities having one Engineering School and one Business School on the same campus.

183 volunteer students participated to the experiment (6 sessions of about 30 students each) mainly enrolled in Telecom and Computer Science majors (from the Engineering School) for 5 sessions and only one session in Finance (from the Business School). Participants were undergraduate students (BSc, bachelor degree).

In order to motivate them, students who volunteered to participate in the experiment received extra credit in one of their subjects.

For the group composition, we had 60 teams; 3-4 person teams with a good representation of gender (61% male – 39% female) and nationalities (14). Participants were 19-24 year old (with an average age of 21.27) and may not know each other before. All participants have attended a course on Information System Design that has been part of their academic plan.

Procedure (Experiment Script):

The setting of this experiment was with two treatment conditions: Skype use and Second Life use (Lean media, communication only vs. Rich media, virtual co-presence/world). The purpose of the experiment was a Brainstorming task aiming to deliver a SWOT analysis that evaluates the introduction of a new Information Technology in a given company.

Each participant received the same overview description of the requirements and constraints of the new IT to be designed and implemented in this company. A five pages French-written document was distributed one day before the experiment to all participants. No explanation was given on the nature and the purpose of the experiment beforehand. Participants were asked to test Skype and Second Life setting configuration and features one week before the day of the experiment.

During the experiment, 30 teams used Skype, while 30 other teams used Second Life. The subject of the brainstorming task was presented as follows:

"*A company, whose field of activities is in the local tourism in the northeast of France (skiing, hiking, paragliding, cultural and historical tours, local gastronomy, architectural art, etc) wishes to implement a new Information System capable of supporting its activities of customer relationship, management and marketing. With a quasi-manual current system, it can no longer provide best bookings for its clients, managing schedules of its programs and collaborators, billing, advertising… For this, this company asked the service of a specialist companies in the field of IT consulting and engineering to assist it in the design and the implementation of a new IT…*"

Students have used Skype and Second Life from their campus rooms, in the labs or through the campus Wi-Fi (despite the freedom to select any of these alternatives, members of the same team were not physically located in the same area). The experiment was conducted in one hour-long session. The experiment process treatment applied to each of the two teams as follows:

- ***Skype users:*** For these teams, the session starts with the reception of an email from the investigator/instructor explaining the purpose of the experiment, the working process of the session and the required deliverable. Then when ready, participants were asked to log in and confirm their username (composed by their team number and participant number; e.g. Team1-P1) on Skype to the instructor by a small text message. After, each team was required to brainstorm during 30 minutes and build collectively a SWOT grid. The team was suggested to provide their deliverable at the end in electronic or paper format by one participant of the team. After delivering their SWOT analysis, teams were asked to meet in the classroom with the instructor and to fill in the questionnaire survey.
- ***Second Life users:*** For these teams, the session starts with the reception of an email from the investigator/instructor explaining the purpose of the experiment, the working process of the session and the required deliverable. Then when ready, participants were asked to join the investigator on the virtual campus on Second Life and confirm their identity through their avatar name (composed by their team number and participant number; e.g. Team1-P1). After, each team was required to find a place on campus and to brainstorm in 30 minutes and build collectively a SWOT grid. The team was suggested to provide their deliverable at the end in electronic or paper format by one participant of the team. After delivering their SWOT analysis, teams were asked to meet in the classroom with the instructor and to fill in the questionnaire survey.

The questionnaire was distributed in a paper format. Only two participants did not volunteer to answer the survey after the experiment. Collected responses were administrated electronically by a third person (a PhD student) through Qualtrics Survey Software in order to allow analyzing the data through the statistical software.

5. Measures

Measures in the survey were retained from earlier researches that tested the scales in different research settings and succeeded to validate their use in these contexts. Team performance was measured by the scoring of each team. Cognitive Absorption was measured using items adapted from Agarwal and Karahanna (2000). To measure Virtual Co-Presence, we adapted measures from Bailenson and Yee (2006). Diversity Indexes were calculated using Blau's (1977) diversity index: $1 - \Sigma p$.

Additionally, we controlled Age Diversity, Team average GPA, National Diversity, European Citizenship Diversity, Gender Diversity and Past Use into Cognitive Absorption. The following table provides the constructs used in this study and their items.

Cognitive Absorption (Agarwal and Karahanna 2000)
Temporal Dissociation
Time appears to go by very quickly when I was using Second Life.
Focused Immersion
While using Second Life I was able to block out most other distractions.
Heigtitened Enjoyment
I had fun interacting with the Second Life.
Control
COI. When using Second Life I feel in control
Curiosity
Using Second Life excites my curiosity,
Co-Presence (Bailenson and Yee 2006)
I perceived that I was in the presence of other people in Second Life.
I felt that people in Second Life were watching me and were aware of my presence.
The thought that they were not real people crossed my mind often in Second Life/Skype
People in Second Life/Skype appeared to be sentient (conscious and alive) to me.
I perceived people as being only a computerized image, not as real people while using Second Life (RC)
Density (Blau 1977)
How much did you depend on _____?
How much did _____ depend on you?
How much did you work with _____?
How much did you communicate with _____?

Table 14 Constructs and their items

6. Results and Analysis

Results from the measurement and structural models are displayed in the following tables and figures. However, in order to ensure first that we got a data of good quality we assessed the common method bias that could be induced through the data collection method adapted.

Common Method Variance

Cross section data collected using survey as data collection mean has the potential to suffer from common method variance (CMV). We conducted Harman's single factor test to fully investigate the possibility of CMV. We ran an exploratory factor analysis. Common method variance is said to exist if the first factor accounts for the majority of the variance in the variables. The first factor explained only 38% of the variance. Since the value was less than 50%, we conclude that common method variance was not a major issue.

	Composite Reliability	1	2	3	4	5	6	7	8	9	10	11
Performance	(N/A)	(N/A)										
Gender Diversity	(N/A)	**0.283**	(N/A)									
National Diversity	(N/A)	-0.055	0.166	(N/A)								
Eurpean Citizenship Diversity	(N/A)	0.119	0.109	**0.708**	(N/A)							
Team GPA	(N/A)	-0.172	**-0.236**	0.065	0.126	(N/A)						
Age Diversity	(N/A)	0.022	-0.197	0.164	0.01	0.147	(N/A)					
Skpe/Second Use	(N/A)	**0.222**	-0.011	-0.018	0.033	0.13	-0.015	(N/A)				
Density	(N/A)	0.015	**0.348**	0.1	0.104	-0.101	**-0.349**	**-0.354**	(N/A)			
Past Use	(N/A)	-0.14	**0.397**	-0.042	-0.084	0.026	**-0.345**	-0.09	**0.443**	(N/A)		
Virtual Co-Presence	0.807	**0.212**	**0.292**	-0.023	-0.002	-0.045	-0.111	**0.309**	**0.285**	**0.421**	0.77	
Cognitive Absorption	0.923	0.179	-0.146	0.019	-0.079	0.143	**0.254**	**0.707**	**-0.542**	-0.13	**0.257**	0.84

Sqrt AVE along diagonals; Significant Correlations are in bold.

Table 15 Measurement Model

	Variables	
	Co-Presence	**Cognitive Absorption**
COPRE1	.084	**.90**

COPRE2	.40	**.70**
COPRE4	-.02	**.89**
CATD	**.85**	-.07
CAFI	**.86**	.12
CAHE	**.83**	-.06
CACO	**.73**	.25
CACU	**.82**	.00

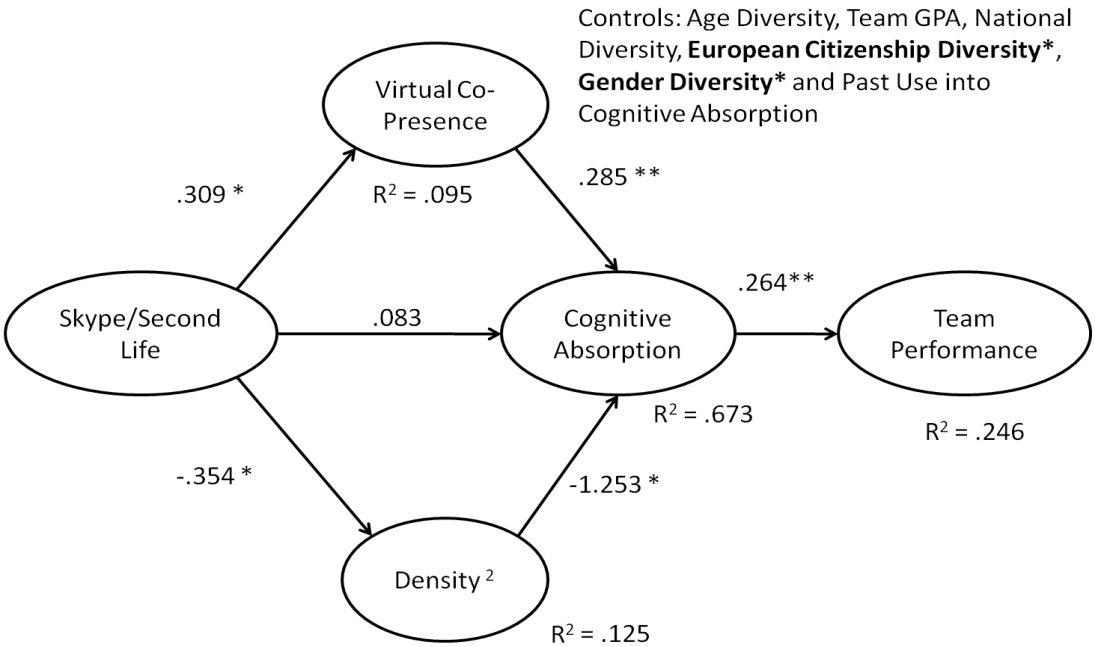
Table 16 Cross loadings

Constructs Validities and Reliabilities

In order to assess and validate the measurement model we first examined the constructs' reliabilities. Results including item loadings and construct reliabilities are summarized in Table 14 and Table 15. Construct reliabilities are above the acceptable threshold of .70, an indication of convergent validity (Hair et al. 2010).

Discriminant and convergent validity of the constructs was assessed using two methods. First, discriminant and convergent validity were assessed using factor analysis. According to Chin and colleagues (1995; 1996), we assess them by checking for cross loading (Chin 1995; Chin 1998; Chin et al. 1996). The results including item loadings and construct reliabilities are summarized in Tables above. The results indicated that all items, except one, had loadings above the acceptable threshold of .70 (Hair et al. 2010). Chin provides two guidelines to help determine convergent and discriminant validity (Chin et al. 1998; Chin, 2003). One, items should load higher on their corresponding constructs than on other constructs. Two, items should load higher on their corresponding constructs than any other items measuring other constructs. Looking at table 14 we can confirm that our measurement model satisfies the two criteria suggested by Chin and colleagues (1998). In addition all items, except one had loadings above the acceptable threshold of .70 (Hair et al. 2010). While correlation appears significant between some constructs, looking more closely into cross loadings the constructs are well represented through their respective items as they still load higher with their respective constructs than with correlated constructs. Additionally, discriminant validity was again assessed through Average Variance Extracted (AVE) that examines if the items of a construct share more variance internally than with any other constructs in the model (Hair et al. 2010). The average variance shared is shown along the diagonals of the correlation matrix. In these tables,

the AVE of each construct is larger than the average variance of the construct with the others constructs which indicates adequate discriminant validity (Hair et al. 2010). Overall, both tests provide support to discriminant and convergent validities of the measurement model.



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

Figure 8 Structural Model: Hypotheses tests

In the aim to test the construct validity of the formative consruct Density, we followed the recommendations of Petter et al 2007 by inspecting the weights of each item of the inner model. We examined the variance inflation factor (VIF) which should be less than 3.3. VIF score was found 3.02. The weights were found (D1= .87, $p<0.05$; D2= .74, $p<0.01$; D3= .68, $p<0.01$ and D4= .92, $p<0.01$).

Hypothesis Testing

The proposed model was tested using Partial Least Squares (PLS) using PLS Graph 3.00. Figure 8 presents the results of the model. Generally all hypotheses were supported.

7. Discussion and conclusions

This research examines the impacts of co-presence, facilitated by contemporary technologies, on the performance of a virtual team. Prior research examines impacts of different media types on performance (Dennis et al. 2008). However, in this research we extend the findings by developing new theory on the process of these impacts. Specifically, we open the black box of the technology impacts by focusing on two behavioral pathways that mediate the impacts of virtual environment on team performance. Specifically, we examine mediating impacts due to two salient dynamics – cognitive absorption, and co-presence.

We ran incremental models to test these effects. Firstly, we established the positive impacts of co- presence on overall team performance. Positive effects of co-presence were found on organizational performance. Further, we find that these impacts are positively mediated by cognitive absorption, and density. Thus, the creation of digital co-presence facilitates greater team absorption in the task. In summary, the overall impacts of the digital co-presence are positive, but interestingly they are mediated by cognitive absorption.

Significantly and simultaneously affected by co-presence and density, cognitive absorption impacts significantly team performance (path coefficient= 0,264, p= 0,05). Assessing the moderating effect of the nature of the technology (Skype or Second Life) on team performance, results confirm results shown in prior research that examined impacts of different media types on performance (Dennis et al. 2008). The results report that Second Life can enhance considerably teams' collaboration, while Skype would do less. Significant mediating effect of cognitive absorption shows the importance of the co-presence feeling although the density is minimized. The overall result shows that high cognitive absorption conditioned by high co-presence and low density facilitates enhancing team performance.

The results reported from Second Life teams are witnessing a different impact from those reported from Skype ones. Team performance was found to be different which asserts that the type of technology has an impact on team performance. This has been reported before from the literature of virtual teams. In this study, we found the same after comparing a 3D virtual worlds and Skype.

The interaction between different team members was found to facilitate smooth interactions in Second Life, as the technology allowed better freedom of the user comparing to Skype were user is only using a voice communication with teammates. In Second Life, participants were found more excited with this nice designed technology; they have the possibility to shake hands, to touch objects, to select appearance or to use gestures.

The deep sense of co-presence is influencing the attitude of users depending on how comfortable they are with the technology. However, when the density of the interaction is full, and as this relates rather to human interaction, the cognitive absorption is weak as key attention is given to the interaction related aspects rather than the system used and the general feeling toward the time, curiosity and enjoyment. On the other hand, the use of one of these two collaboration technologies would lower the sense of density, as they would be considered barriers to direct and live interaction where density is full with real representations.

Firstly, mediation by cognitive absorption helps understanding the dynamics related to IT impacts, i.e. sense of co-presence should be sufficient enough in teams using virtual environments to realize greater impacts on performance. Thus, if team members are able to realize a state of greater flow, immersion, control, they are able to perform better. The mediation by cognitive absorption shows that it is essential to realize the impacts on team performance. In other words, if cognitive absorption is not created due to the sense of co- presence by team members the organizations may not be successful in realizing the impacts on technology on performance. Further, since our examination of virtual co-presence is in the context of group work, group interactions are an important element in our analysis. Team members interact in groups to know each other personally, and to gain task related knowledge. Thus, in this research we assess how the group interactions influence team performance in virtual environments. Specifically, we find that in virtual environments group interactions have an inverted U effect, i.e. they enhance the performance of team members initially, but the team performance is negatively affected when the interactions cross a certain threshold.

Limitations

For this study, the increased control afforded by a laboratory experiment must be traded off against the inherent limitations of the approach, primarily that of generalizability. The use of student subjects may limit the generalizability of our results. Student subjects typically differ from business professionals because they may have less experience with the problem domain, or may have lesser motivation to perform the task successfully. In this study, both these factors were considered while choosing the subject pool and designing the experimental task. Subjects had enough knowledge and were incentivized. In addition, the quality of the students' effort during the study (e.g., assignment for the student), was linked to points earned in the class. While in our manipulation of co-presence we relied on two technologies. Similarly, More research, however, is needed to examine the generalizability of our results to other settings and technologies.

Next, we elaborate on the key contributions of our study to the IS literature. There is a growing trend within organizations to use advanced information technologies to substitute physical means of face-to-face interactions. However, little is understood regards how these technologies may influence performance. While there is greater traction for use of virtual environments because of these being low cost alternatives to doing more advanced managerial work, such as strategic planning etc., there is little rigorous examination of the pathways through which these technologies may enhance performance. Hence, our research highlights the dynamics that characterize efficient and effective use of these technologies. Hence, our findings have important implications on how to leverage these technologies for creating greater organizational value.

Besides contributing to managerial knowledge regards leveraging information technologies, we also bring to fore the dynamics related to co-presence. With a nascent yet growing interest in the concept of co-presence, our study contributes greater understanding of the concept by examining the mediated impact dynamics. While we show the increased relevance of information technologies in harnessing co-presence more research is needed to examine how technologies may differ in their ability to create co-presence. Further, while in this research, we examine one dynamic, that of co-presence, more research is needed to fully unravel the value

creating processes that may influence use of virtual environments for group-work in organizations.

In summary, our research has tested the impacts of a new dynamics and brought to fore the mediating impacts of two constructs – cognitive adoption and co-presence. This study is more centered on the understanding of VWs dynamics rather than videoconference with Skype. Given the increased focus on virtual environments as substitutes of face-to-face work, our examination of one relevant and contemporary dynamic - co-presence – will enhance the managerial adoption and use of these technologies for core business tasks. This research will form a foundation for a growing and important stream future research examining these dynamics.

CHAPTER VII: SECOND QUANTITATIVE STUDY

"You can use all the quantitative data you can get, but you still have to distrust it and use your own intelligence and judgment."
Alvin Toffler[31] (1928-*)

[31] American author and futurist.

1. Introduction

Collaboration is considered as an important competency for organizations that wish to leverage collective intelligence and maximize productivity (Drucker 1989; Nunamaker et al. 1998; Nunamaker et al. 2002). Effective collaboration is considered as a key success factor and competitive advantage of today's organization (Kock 2008) since it reinforces knowledge sharing and enhances knowledge development and application. In an environment where technology gains incremental advances for media communication, virtual collaboration is being enabled, adopted and fostered (Boughzala et al. 2012).

Indeed, individuals are invited to collaborate with other teammates all over the world and they are no longer limited or expected to interact with them directly in a face-to-face setting. According to Griffith and colleagues (2003), new technology would expand the opportunities for teams to collaborate more and would make them more effective (Griffith et al. 2003). In this study we refer to 3D VWs are 3D virtual environments where users interact via avatars.

They are enrolled in the 3D trend as a new and promising collaboration tool providing rich and interactive media. They provide team members with new ways to manage and overcome several barriers to face-to- face collaboration (Davis et al. 2009). In addition, these 3D environments have been found to increase group-oriented learning (Suh and Lee 2005) and process engagement (Franceschi et al. 2009). Thus, 3D VWs have potential for richer and more engaging collaboration (Davis et al. 2009). Further, regarding the benefits of global collaboration in VWs, there is an increasing demand by multinational corporations to implement 3D VWs in order to improve their work processes (Wasko et al. 2011). Nevertheless, using them in professional settings is still surrounded with much hype as their capabilities have not been yet deeply explored (Davis et al. 2009). In fact, studies in this subject should allow a clear vision with VWs lenses of this new kind of collaboration with respect of the specificities of these new media. Thus, research needs to inform and help organizations to optimally benefit from 3D VWs assets (Boughzala et al. 2012; Wasko et al. 2011). There is a need to develop theoretical understandings of the fit between collaborative tasks and VW capabilities and processes (Boughzala et al. 2012). Indeed, we are interested more specifically in this challenge.

Several research teams have embarked on the study of 3D VWs such as learning (Davis and Zigurs 2008; Franceschi et al. 2009), project management (Owens et al. 2009), brand equity (Nah et al. 2010), collaboration (Chandra et al. 2012; Nardon and Aten 2012; Schmeil et al. 2012; Venkatesh and Windeler 2012). However, researchers studied specific factors influencing collaboration such as task complexity (Nah et al. 2011), cognitive absorption (Chandra et al. 2012; Goel et al. 2011), personality traits and group cohesion (Venkatesh and Windeler 2012), adoption of VWs in work spaces (Chandra et al. 2012; Nardon and Aten 2012), flow and presence (Animesh et al. 2011).

While these considerations are crucial, these factors and many other factors (e.g. Knowledge sharing and social loafing) were approached qualitatively through personal observation of the collaborators behavior or through their data available on the 3D platforms. On the one hand, relevant constructs such as knowledge sharing, knowledge application and social loafing have not been studied quantitatively through the team members' perceptions of their use of these technologies and impact on their work.

On the other hand, object manipulation and customization effects, as key specific features of 3D VW environment, have not been assessed in the context of teamwork. This chapter brings a literature review and builds up a research model that addresses the theoretical gap from the literature. It presents a quantitative study that tries to test the research model. This research is an attempt to answer a business need of organizations willing to use 3D VWs in workspaces if its positive developing impact could be approved.

2. The research model

VW Technology usage

In human and computer interaction, a recent analysis (Sun and Teng 2012) reviewed technologies and information system use comparing to other researchers who focused mainly on team related tasks performed on the system. This analysis argues that main activities performed around the technology usage are information reporting, group tasks performance and decision-making. According to Sun and Teng (2012), the construct technology usage is composed from three main dimensions

namely information reporting system, decision support system and group support system.

- Information Reporting System (IRS) usage: this dimension is related to the reporting function of the group. It provides timely information about internal activities of the team usually operations and performance. It aims at supporting the monitoring and control functions of management.
- Decision Support System (DSS) usage: this dimension aims at fostering decision-making. It enables team members to do exploratory analysis and to be more creative. It includes simple model-based systems, advanced modeling techniques, and data-based systems.
- Group Support System (GSS) usage: this dimension is focused on the set of technologies fostering communications and collaboration within a team mainly by sharing knowledge between members (Klein et al. 2007).

We differentiate between the use of technology and the usage of technology. The first is to utilize or to employ a technology. The difference between the use and the usage is that the usage reflects the continuity of the act of using the technology.

In this research, we will go more deeply in details to understand in the context of virtual worlds, the impact of technology usage on collaboration. The most interesting dimension in the case of our study is GSS usage since it tries to measure the usage of technology to support team collaboration. In our analysis, we will be more focused on the impact of group support system usage.

In the specific context of this study, we argue that high usage of these technologies would enhance the workers willingness to share knowledge with their collaborators. Technologies have found to be encouraging teamwork (Griffith et al 2003). Bock and colleagues (2005) and Choi et al (2010) argue the importance of technology to facilitate knowledge sharing within team members. Yet, the more advanced an individual is in the 3D technologies usage, more specifically, the more each employee is able to manipulate an object and the more customizable the virtual working environment is. Consequently, the employee would be more willing to share and spread knowledge with his/her collaborators. We suggest our first proposition about the considerable impact that high usage of 3D Technologies would have at boosting

knowledge sharing and we develop particularities about 3D virtual world with the object manipulation and customization subsections below.

Hypothesis 1: VW Technology usage (GSS usage) is positively related to knowledge sharing.

Knowledge sharing

Defined as the willingness of individuals in an organization to share their own knowledge (Davenport and Prusak 1998), knowledge sharing is a voluntary action by which knowledge is being spread and made known to others (Cramton 2001; Cummings 2004; Davenport and Prusak 1998). Yet, knowledge is considered as crucial resource for organizational growth and competitive advantage. Thus knowledge sharing is found to be tremendously relevant for firms' development (Bock et al. 2005; Wang and Noe 2010; Wasko and Faraj 2005). The literature argues that information technology usage to support knowledge sharing leads to more effective knowledge sharing in teams (Choi et al. 2010). Indeed, knowledge sharing is considered as a key success factor for collaboration (Grant 1996) entailing risks and benefits for organization (Constant et al. 1994; Cummings 2004). Further, this behavior could be influenced by the IT support, the team members' behavior and the organizational context (Wang and Noe 2010).

Knowledge application

Knowledge sharing is not sufficient; teams must apply it effectively in the aim to deal with given challenges (Alavi and Leidner 2001; Alavi and Tiwana 2002; Choi et al. 2010). Knowledge application is a key individual capability which is considered as "the crux" of knowledge management in organizations (Alavi and Tiwana 2002). It may lead to value creation once knowledge is shared, integrated and applied where it is needed (Alavi and Tiwana 2002). Indeed, knowledge application is the valued concretization of individual and organization knowledge, since most shared knowledge is not effectively applied (Pfeffer and Sutton 2000). While knowledge sharing increases, it underpins favorable setting to apply more the acquired knowledge. Additional alternative solutions to concurrent issues with the work environment facilitate to apply knowledge acquired earlier from teammates. (Choi et al. 2010) support this proposition. Choi and colleagues (2010) argue that knowledge

application is positively related to knowledge sharing in virtual teams (not 3D virtual worlds).

Hypothesis 2: High knowledge sharing has a positive impact on knowledge application.

Social loafing

Social loafing is defined by Latané et al. (1979) as "a decrease in individual effort due to the social presence of other persons" (Latané et al. 1979) p. 823. Later Williams and Karau (1993, 681), redefine it as the tendency for individuals to expend less efforts when working collectively than when working individually. The concept of social loafing can be traced back to the publication of (Ringelmann 1913) as a result of several agricultural experiments studying the efficiency of animals, men and machines in various agricultural applications (Kravitz and Martin 1986). According to George (1995), this phenomenon occurs in a wide variety of tasks in laboratory settings (e.g. (Brickner et al. 1986; Jackson and Williams 1985; Kerr and Bruun 1981; Petty et al. 1980; Zaccaro 1984)) and laboratory studies of social loafing are generalizable to workers in the professional context (George 1992; George 1995).

Further, research reported a strong perception of social loafing in classrooms, laboratories and in work places as well (Karau and Williams 1993). According to George (1992) this phenomenon is considered as a widely accepted explanation for productivity losses (Liden et al. 2004). Social loafing has been found to negatively impact team performance specially in a virtual world settings (Suleiman and Watson 2008). Shiue and colleagues (2010) argued that this behavior is a key obstacle to fostering online community development (Shiue et al. 2010) and seriously corrode group cohesion (Shiue et al. 2010). A number of studies have studied the behavior of lurker (individuals who exhibit social loafing behavior) in the online environment (Lin and Huang 2009; Tan and Tan 2008). Some studies reported that social loafers constitute over 90% of several online groups (Mason 1999; Shiue et al. 2010). According to Wasko and Faraj, lurkers are taking advantage of the knowledge provided by other team members without sharing anything in reciprocity. So, knowledge contributors will be less motivated to share their knowledge (Shiue et al. 2010).

Liden and colleagues (2004) investigated a set of antecedent to social loafing categorized on two levels namely; individual level containing task visibility, task interdependence and distributive justice and a group level containing work group size and group cohesiveness. They argue that the study of the antecedents of this behavior will give ideas to remedy this problem. A number of other antecedents have been found from several studies such as lack of identification of individual contributions to the group (Williams et al. 1981); lack of challenge and uniqueness of individual contribution (Harkins and Petty 1982); low intrinsic involvement (Brickner et al. 1986; George 1992); low group cohesiveness (Karau and Williams, 1997) etc. Whereas, lack of motivation is considered as the most important antecedent to social loafing (Liden et al. 2004; George 1992).

The literature has differentiated between social loafing, perceived loafing and free-riding. Perceived loafing is defined by Comer (1995) as the perception that one or more other teammates are contributing less than they could to the teamwork (Comer 1995). Author distinguishes between perceived loafing and free-riding. This latter is very similar to social loafing and occurs when some group members are working on public goods and perceive that other group members will put forth effort to make their own contribution unnecessary to receive the public goods (Mulvey and Klein 1998).

Social loafing will not only negatively impact the individual performance but it will have consequences on team members when this behavior is perceived. Mulvey and Klein (1998) argue that one key consequence of the perception of loafing is reducing the motivation of the group members working with lurkers[32]. Further, perceiving lurker behavior could lead group member to expand less effort themselves (Albanese and Fleet 1985; Veigal 1991) thus the team performance is dropping (Kerr and Bruun 1981; Mulvey and Klein 1998). Finally, Jackson and Williams (1985) asserted that, under specific circumstances, social loafing may lead to reduced stress and subsequent performance (Jackson and Williams 1985). Research has argued that social loafing within physical work environments would also have similar effects within technology-supported work environments (Suleiman and Watson 2008). In addition, several studies argued that social loafing is negatively related to team cohesiveness (Karau and Hart 1998; Karau and Williams 1997), this behavior has

[32] Loafer

been found to negatively affect group members who carry the weight of the group mainly the team leader (Hardy and Crace 1991). Social loafing has been found to negatively impact knowledge sharing (Wasko and Faraj 2005). Lin and Huang (2008) argue that social loafing has a negative impact on knowledge contribution and sharing.

Hypothesis 3: Social loafing is negatively related to knowledge sharing.

Object manipulation

Object manipulation refers to the ability to reach out a hand, grab an object, and move it around the virtual environment using natural, physical motions (Robinett and Holloway 1992). This feature allows users to touch and manipulate objects virtually (Ruddle et al. 2002). Object manipulation is considered as a crucial asset of 3D VWs as it makes them a metaphor of real life (Ruddle et al. 2002). Further, earlier research asserts that object manipulation evokes corresponding vivid mental images and increase intentions of object use regardless of users' goals (Schlosser 2003). In addition, VWs are considered as rich media and allow interactivity between avatars (Davis et al. 2009; Franceschi et al. 2009; Suh and Lee 2005). As rich media impact the level of communication and then the social interaction (Daft and Lengel 1984; Daft et al. 1987), mastering the usage of these media could lead to enhanced level of communication between users in a distributed team (Majchrzak et al. 2005) which will increase knowledge sharing.

Hypothesis 4: Object manipulation will positively moderate the effect of VW technology usage (GSS usage) effect on knowledge sharing.

Customization

Customization is about changing the appearance of the avatar or the environment around the avatar (Ducheneaut et al. 2009). It gives users the ability to customize their profiles and the working environments in the aim to be more at ease in workspace.

In our exploratory study, we identified personalization as candidate to be an important factor fostering team collaboration. However, in the literature we discovered that personalization and customization are two different concepts. According to Kobsa et al (2001), customization is the ability to change or modify the

service (the avatar or the environment) with the means provided by the virtual world. Whereas, personalization is the fact of appropriating the service (virtual world) and being able to bring new content which is not proposed by the virtual world. In this research, we are interested in the concept customization rather than personalization.

Customization serves to facilitate human-computer interaction, ease of use and would improve user response (Suh et al. 2011). In these VWs, users are able to customize their environments (i.e. creating and buying new decors) and also shaping their own appearance to be similar to themselves (Suh et al. 2011). Other users may choose an 'ideal' appearance which they would like to have. Customizing an avatar appearance is considered as a rich capability afforded by the media (Davis et al. 2009; Suh et al. 2011). Researchers argue that customization add more enjoyment to the virtual experience and increases the feeling of presence and immersion (Bailey et al. 2009; Ruddle et al. 2002; Teng 2010). Furthermore, Suh and colleagues (2011) reported that the more closely an avatar resembles its user, the more the user is likely to have positive attitudes in 3D VWs. Consequently, users who are the most able to customize their own avatars the closer to their preferences will be more willing to interact with others and share knowledge with them.

Hypothesis 5: Customization would positively moderate the effect of VW Technology usage (GSS usage) on knowledge sharing.

Individual performance

The literature of virtual teams argues that individuals could use technology to assist themselves in the performance of their tasks (Goodhue and Thompson 1995). Indeed, technology is found to be a crucial element expanding the opportunities for more effective teams (Griffith et al. 2003). More precisely, IT is more likely to positively impact individual performance if the capabilities of the technology are matching with users' tasks. According to Goodhue and Thompson (1995), individual performance is influenced by the experience with technology. As knowledge is acquired, shared and applied by individuals (Choi et al 2010), the application of the shared knowledge may have a positively affect individual performance as it allows the development of new skills.

Hypothesis 6: Knowledge application is positively related to individual performance.

Hypothesis 7: Individual performance is positively related to team performance.

In order to test the hypotheses we examine how the research model fits with the data collected in the usage of two different collaboration technologies.

The study is run through a quantitative research that allows assessing the impact of VW use and social loafing on knowledge sharing and knowledge application in the 3D virtual world setting. The empirical study would allow assessing whether collaboration and social loafing are of similar weight and impact across these organizations.

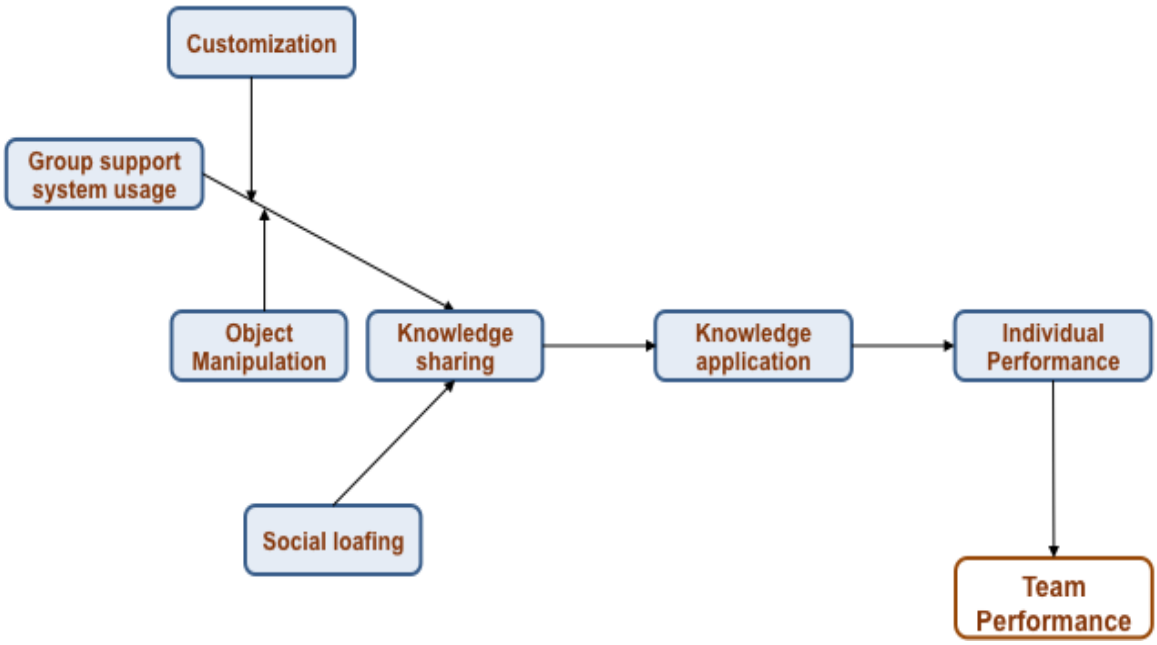


Figure 9 The research model

3. Data collection Method

A survey was developed for the purpose of this study. Items to measure respective constructs were selected from earlier validated scales and scales in their earlier versions that were adapted to virtual world analyzing context. Additionally, we here adapted the social loafing scale to 3D virtual environments and developed the object manipulation scale based on a validated taxonomy about object manipulation in 3D virtual worlds and using the Churchill new scale development process.

We adopted a snowball data collection technique. We collected 247 responses, 144 were valid (complete responses).

We used an online questionnaire to empirically validate our hypotheses. Our research model has been operationalized and transferred into a structural equation model and were analyzed later using the Partial Least Squares (PLS) approach. Each construct is represented by a set of reflective and formative indicators which are given in Appendix 11 (questionnaire) the references are given in the table 18. The indicators were adopted from the relevant literature. For the evaluation of the research model data of individuals with different background and experience with virtual worlds was collected within a general study of IT usage. The total number of targeted audience of our questionnaire was about 2500 people.

- The questionnaire was sent to several lists of people working on virtual environments provided in the following table:

List	Description
Educators	SL Educators (The SLED List)
Exchanges	Second Life L$ exchange operators
opensource-dev	Open source development issues relating to Second Life
SLBusiness	Public list for developers and businesses interested in discussing commercial applications of SL
Open-sim developer	Developer on open sim virtual platform

Table 17 Lists of people working on virtual worlds

- It was also spread inside two companies working inside Second life (Podex[33] money exchange) and Avalive[34] technology. The questionnaire was spread inside the virtual world.
- A third list was spread through Pennsylvania university mailing list (virtual worlds).

Participants

Based on measurements from literature, a quantitative questionnaire has been prepared to VWs' users who are collaborating through VWs. This questionnaire takes into account different constructs announced below. The questionnaire was pretested

33 http://www.podex.info/
34 http://wa11137.avayalive.com

with four workers in 3D virtual environment. First feedback shows that the items cover well key aspects to consider in VW technologies use. The questions also appeared to be clearly understood by the respondents. Some insights and comments have been extracted in the aim to enhance the questionnaire and make respondents have better understanding of the questions. The survey was addressed to workers using 3D VWs in their workspaces. The sample includes people from a large number of companies and organizations that operate in different fields.

Gender	Female	60	41.7%
	Male	84	58.3%
Age	Less than 18	2	1.4%
	18 through 25	9	6.3%
	26 through 35	28	19.4%
	36 through 45	36	25.0%
	46 through 55	34	23.6%
	56 through 65	30	20.8%
	65 and over	5	3.5%
Education	No degree	12	8.3%
	Professional education degree	30	20.8%
	Junior college (License)	6	4.2%
	Bachelor degree	27	18.8%
	Engineering	7	4.9%
	Master's degree	30	20.8%
	Doctorate	32	22.2%
Tenure on the present job	Do not have a job	11	7.7%
	1 year or less	18	12.6%
	2 through 5 years	31	21.7%
	6 through 10 years	27	18.9%
	11 through 20 years	26	18.2%
	21 through 30 years	21	14.7%
	31 and more years	9	6.3%
Experience with 3D VWs	Before 2003	12	8.3%
	2003-2005	9	6.3%
	2005-2007	55	38.2%
	2007-2009	32	22.2%
	2009-2011	20	13.9%
	2011-2013	16	11.1%
Number of virtual worlds		13	
Number of respondents		144	

Table 18 Demographic data

Here is the list of virtual worlds:

Second life
IMVU
There.com
Open sim
vAcadomia

Activeworlds
ICC open quack
Vizard
Entropia universe
Kitely
Osgrid
Haven your world
Open Wonderland

4. Measures

Measures in the survey were retained from earlier researches that tested the scales in different research settings and succeeded to validate their use in these contexts.. The whole questionnaire is provided in appendix 11. The following table provides initial references, references in Virtual Teams of the construct and the reference of the measurement.

Construct	**Initial Reference**	**Reference in VT setting**	**Measurements reference**
Knowledge sharing	(Davenport and Prusak 1998; Grant 1996)	(Davenport and Prusak 1998)	(Choi et al. 2010)
Social loafing	(Latané et al. 1979)	(Shiue et al. 2010)	(George 1992; George 1995)
Customization	(Kobsa et al. 2001)	(Kobsa et al 2001)	(Teng 2010)
Knowledge Application	(Alavi and Leidner 2001)	(Alavi and Leidner 2001)	(Choi et al. 2010)
Object manipulation	(Robinett and Holloway 1992)	--	**New item**
VW technology usage	--	(Burton-Jones and Straub 2006)	(Sun and Teng 2012)
Team performance		(Janz et al 1997)	(Choi et al. 2010; Janz et al. 1997)
Individual performance		(Goodhue and Thompson 1995)	(Choi et al. 2010; Janz et al. 1997)

Table 19 Constructs and their references

Object manipulation

In order to develop a new scale, we followed the steps of the method proposed by Churchill (1979).

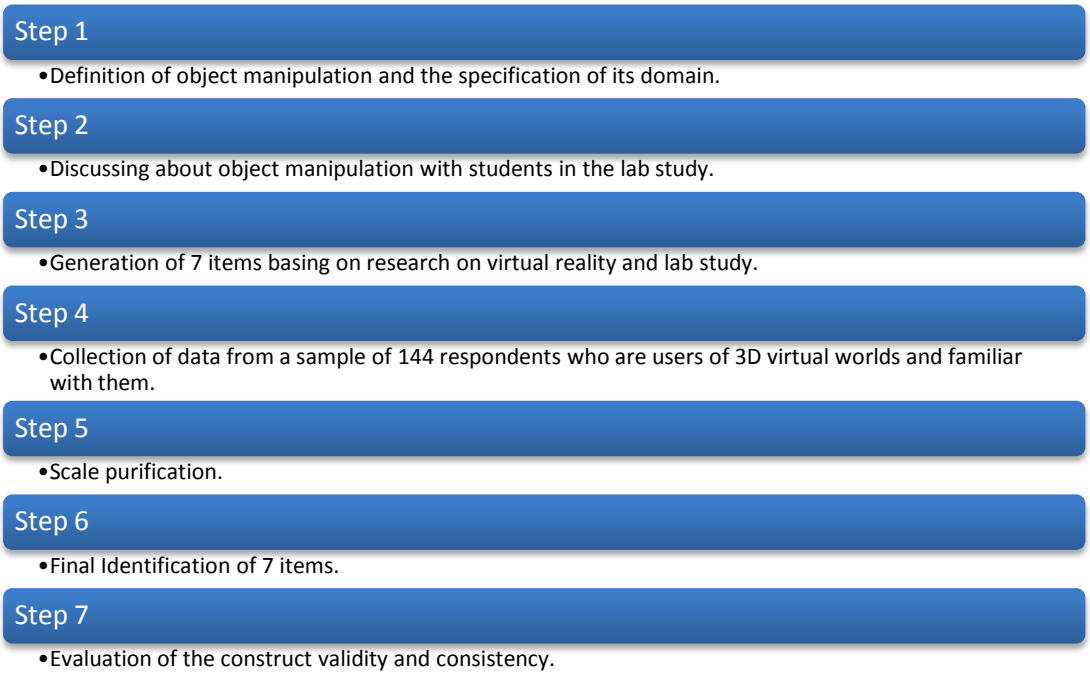


Figure 10 Steps of object manipulation development

Step 1: First, we have specified the domain of the construct and extracted a set of items that describe it. The definition of the word object manipulation was taken from the paper of (Robinett and Holloway 1992). They define this construct as "Reach out a hand, grab an object (using a button or a gesture), and move it around the virtual environment (VE) using natural, physical motions". This definition helped us to delineate what items included and excluded from the construct. We have used the literature about object manipulation in virtual reality[35] (Garb 1987). We have found two taxonomies describing the object manipulation:

[35] Virtual Reality (VR) is a computer-generated environment that could simulate physical presence and imitate real world experience.

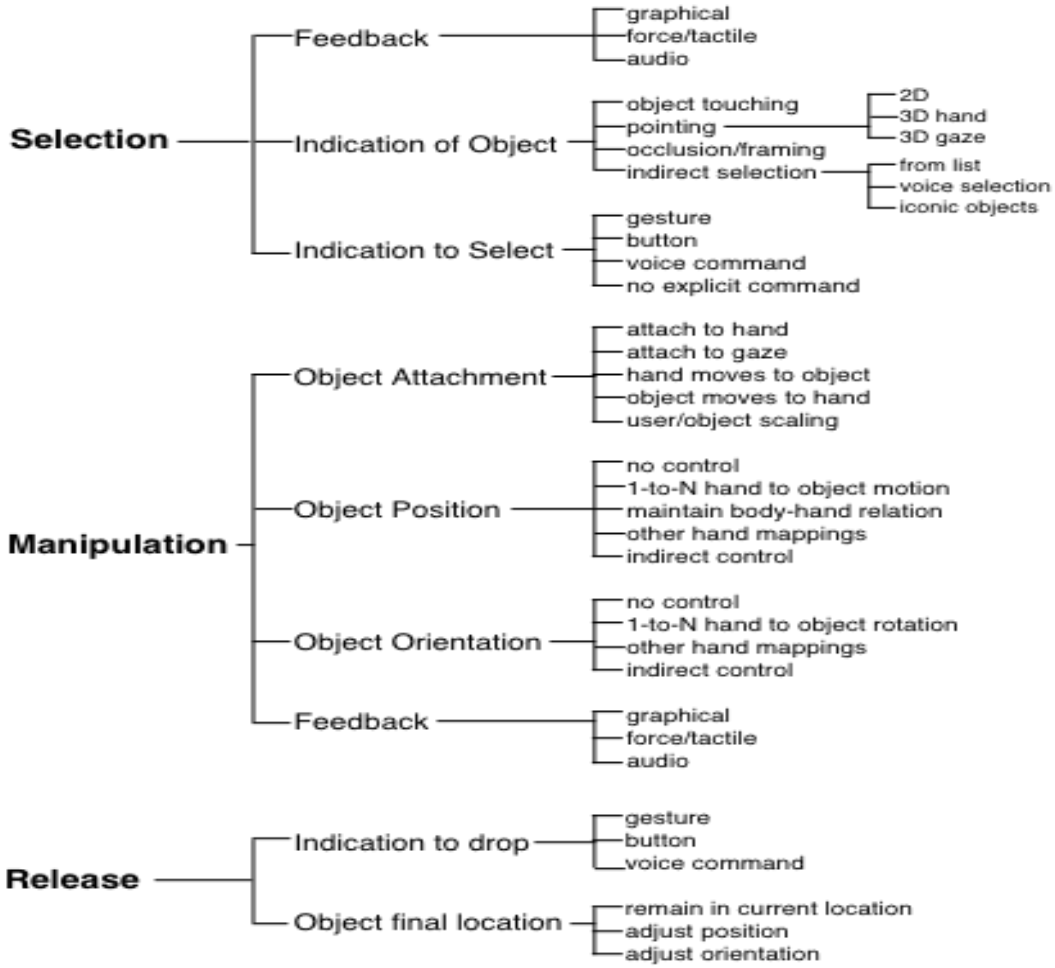


Figure 11 Taxonomy of selection/manipulation techniques in 3D virtual worlds by Bowman (1999)

- (Poupyrev et al. 1998): This study aims at studying immersive object manipulation in a virtual reality setting and comparing the performance characteristics of interaction techniques. This study pointed out strengths, weaknesses and brought guidelines for practical development of object manipulation in a virtual reality setting. The taxonomy provided is very immature comparing to the development of the domain and set of motions provided by virtual worlds.
- Bowman (1999): This study develops and understanding about user interaction techniques and interfaces for virtual environments. It aims at bringing a quantifying the usability of the interface. Bowman (1999) gives a detailed taxonomy of selection and manipulation techniques which is our start point to design our measurement scale (Bowman 1999).

Step 2: Second, we discussed about this 3D virtual world main feature with students in a brainstorming session (Chapter V). Object manipulation is considered as unique asset and very distinguishing feature making virtual worlds a metaphor of real life. Participants argue that this feature could influence team collaboration. Indeed, "touching, grabbing, moving, manipulating object make us feel closer to reality". In addition, object manipulation brings more "vivid interaction and make me feel more comfortable in this environment". One respondent argues that object manipulation makes idea sharing "more interactive and illustrative" which will enrich communication between users and enhance collaboration practice in the team. Object manipulation requires more attention and concentration than any other interaction. The information gathered from students about this construct was relevant to focus more specifically on 7 items from the taxonomies we used.

Step 3: After these two steps, we generated 7 items characterizing the construct. A seven points Likert scale ranging from strongly disagree (1) to strongly agree (7) accompanying each statement.

Object manipulation	1	2	3	4	5	6	7
I can simply select an object							
I can remark some feedbacks when selecting an object such as a sound or a graphical movement							
I can simply touch an object							
Once I selected an object, I can simply move it							
Once I selected an object, I can have control on it							
Once I selected an object, I can remark feedbacks of any control I do on the selected object							
I can simply release an object							

Table 20 Proposal of a measurement scale for object manipulation

Step 4: This step has been described in the data collection method (*3*).

Step 5: This step is performed through an iterative sequence of several sub-steps:

- Computation of coefficient alpha.
- Deletion of items whose removal increased the coefficient alpha.

- Factor analysis to the dimensionality of the overall scale.

The coefficient Cronbach's Alpha of the construct was ***0,9393*** (see table 20) which is acceptable according to (Churchill 1979).

Step 6 and 7: We finally accepted the 7 items presented in the table above. The seventh step consists in the construct validity and consistency. The construct reliability is above the threshold of .70 and the discriminant and convergent validities were validated in the section of constructs validities and reliabilities.

5. Results and Analysis

Results from the measurement and structural models are displayed in the following tables and figures.

However, in order to ensure first that we have a data of good quality we assessed the common method bias that could be induced through the data collection method adapted.

Hypothesis Testing

The proposed model was tested using Partial Least Squares (PLS) using Smart PLS 2.00. Figure 12 presents the results of the model. Generally, all hypotheses were supported.

Common Method Variance

Cross section data collected using survey as data collection mean has the potential to suffer from common method variance (CMV). We conducted Harman's single factor test to fully investigate the possibility of CMV. We ran an exploratory factor analysis. Common method variance is said to exist if the first factor accounts for the majority of the variance in the variables. The first factor explained only 32% of the variance. Since the value was less than 50%, we conclude that common method variance was not a major issue.

	CU	I.P	K.A	K.S	O.M	S.L	T.P
CU	**0.8572**						

I.P	0.1114	**0.6697**					
K.A	0.2063	0.1089	**0.9651**				
K.S	0.1383	0.0983	0.2701	**0.7922**			
O.M	0.3466	0.1516	0.1375	0.1698	**0.7342**		
S.L	0.0295	0.0881	0.0567	0.0897	0.0476	**0.5606**	
T.P	0.1079	0.4253	0.1968	0.2814	0.1221	0.0918	**0.8410**

Diagonals are AVEs; T.P: team performance; I.P: individual performance; K.S: Knowledge sharing; K.A: knowledge application; S.L: social loafing; O.M: object manipulation; CU: customization.

Table 21 Measurement Model

Constructs Validities and Reliabilities

In order to assess and validate the measurement model, we first examined the constructs' reliabilities. Results including item loadings and construct reliabilities are summarized in Table 20 and appendix 12. Construct reliabilities are above the acceptable threshold of .70, an indication of convergent validity (Hair et al. 2010).

Discriminant and convergent validity of the constructs was assessed using two methods. First, discriminant and convergent validity were assessed using factor analysis. According to Chin and colleagues (1995; 1996), we assess them by checking for cross loading (Chin 1995; Chin 1998; Chin et al. 1996). The results including item loadings and construct reliabilities are summarized in Table 20. The results indicated that all items, except three, had loadings above the acceptable threshold of .70 (Hair et al. 2010). Chin provides two guidelines to help determine convergent and discriminant validity (Chin et al. 1998; Chin, 2003). One, items should load higher on their corresponding constructs than on other constructs. Two, items should load higher on their corresponding constructs than any other items measuring other constructs. Looking at table 18 we can confirm that our measurement model satisfies the two criteria suggested by Chin and colleagues (1998). In addition, all items, except three, had loadings above the acceptable threshold of .70 (Hair et al. 2011; Hair et al. 2010). While correlation appears significant between some constructs, looking more closely into cross loadings the constructs are well represented through their respective items as they still load higher with their respective constructs than with correlated constructs. Additionally, discriminant validity was again assessed through Average Variance Extracted (AVE) that examines if the items of a construct share more variance internally than with any other constructs in the model (Hair et al. 2010). The average variance shared is shown along the diagonals of the correlation matrix. In these tables, the AVE of each construct is larger than the average variance

of the construct with the others constructs which indicates adequate discriminant validity (Hair et al. 2010). Overall, both tests provide support to discriminant and convergent validities of the measurement model.

Composite reliability

	AVE	Composite Reliability	R^2	Cranach's α
CU	0.8572	0.9730		0.9669
I.P	0.6697	0.8588	0.153	0.7556
K.A	0.9651	0.9881	0.304	0.9819
K.S	0.7922	0.9581	0.336	0.9473
O.M	0.7342	0.9507		**0.9393**
S.L	0.5606	0.9268		0.9118
T.P	0.8410	0.9407	0.487	0.9054

Table 22 Composite reliability

In order to test the construct validity of formative measures (IP and TP), we followed the recommendations of Petter et al (2007) by inspecting the weight of each item in the inner model (Petter et al. 2007). The following table all the weights were statistically significant at the target construct. In addition, we examined the variance inflation factor (VIF) for both of the formative constructs. According to Petter et al. that VIF should be within less than 3.3. Both VIF scores are found less than 3 (IP = 2.34, TP = 2.88).

Construct		Loading score	t-value
IP	IP1	0.94	10.11^{**}
	IP2	**0.62**	4.15^{**}
	IP3	0.70	4.84^{**}
TP	TP1	0.81	11.82^{**}
	TP2	0.80	6.55^{**}
	TP3	0.84	7.21^{**}

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

Table 23 Loading scores for formative constructs

We studied more on details different dimensions of VW technology usage and study the moderating effect of object manipulation and customization on knowledge sharing. The results show that the effects of Decision Support System usage and Information Report System usage are diminishing the overall influence of VW technology usage. While Group Support System usage is the most influent of the three dimensions of the construct. The following figure shows a change after the

separation of the three dimensions and it highlights the significant moderating effect of customization and object manipulation of the group support system dimension on knowledge sharing.

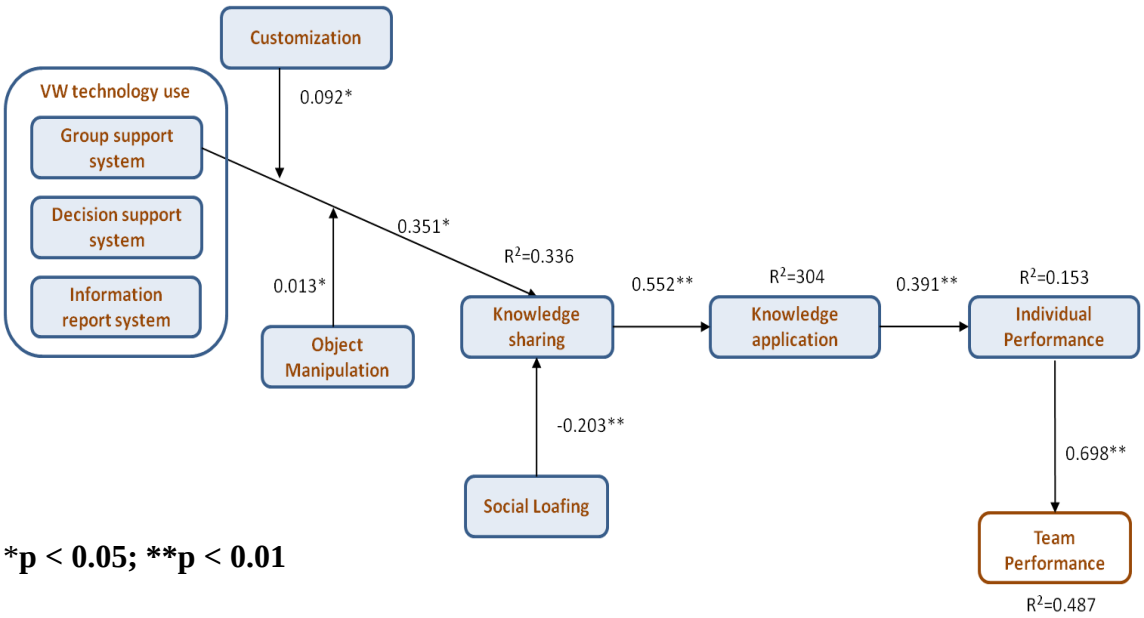


Figure 12 Structural Model

6. Discussion and conclusions

This study examines the impacts of social loafing and knowledge sharing, facilitated by contemporary technologies, on the performance of a virtual team. The impact of technology usage on team performance has been widely studied by the literature (Dennis et al. 2008). However, in this research we extend the findings by examining an emerging media using the lenses of a quantitative study about people working with these media. More specifically, we studied the technology impacts on supporting group collaborative tasks focusing on two behavioral pathways that mediate the impacts of virtual environment on team performance. We examine mediating impacts due to two salient dynamics – object manipulation and customization. These latters are considered as two salient assets of the technology making it more interactive and customized.

In the aim to test the hypotheses, we used SPSS software and Smart PLS. The start point of our model was the technological features of the technology. We established the moderating effect of object manipulation and customization on knowledge

sharing. Positive effect of both moderating variables on the effect of VW technology usage and knowledge sharing. More specifically, the construct VW technology usage has three dimensions and each of them has a different effect on the moderation effect of object manipulation and customization. Indeed, group support system usage has been found to be the most influent on the three dimensions. We studied more in details this dimension as it is focused mainly on collaboration activities within the team. Hence, group support system has been found to be better handled than information report system or decision support system. This may be explained by the nature of technology which fosters a set of activities rather than others. Mainly according to the literature, little has been discussed about decision-making or information reporting on virtual worlds. Activities are more focused on knowledge sharing, learning, attending conferences, etc. In the same time, object manipulation and customization have been also found to be significantly moderating group support system on knowledge sharing. Hence, manipulating objects could be more interesting in collaborative activities rather than reporting or decision-making. However, customization could be important for all of them because it's not related directly to the type of activity, as it has an effect on the well being of the person with his/her own avatar or the customization of the environment to be more helpful and pleasant for work. Customization has been found to take a consequent time of users (Suh et al 2005) which could have a negative effect on their productivity. So this feature should not be a goal in itself, it should not take much time.

In the same time virtual worlds' users were found to be more excited with the nice design of technology as they have the possibility to shake hands, touch objects, select appearance or use gestures while all these interaction are not possible in usual technologies such as voice communication or email. These technological features brought by virtual worlds allow users to have the possibility to simulate the use of product or to present a new system to others. This permits a more interactive experience when working together in a virtual environment.

This could have a positive effect on the attachment of workers to their workplace and spend more time working and exchanging information.

The experience with the technology could have a non-negligible effect on the ease of use of features brought by virtual world life.

Social loafing has a negative effect on knowledge sharing (path coefficient= -0.203, p= 0.05). Results confirm findings shown in prior research that examined impacts of social loafing and the behavior of loafers on team performance (George 1992, 1995). It could also have an impact on the behavior of teammates and the overall collaboration process. The results report that social loafing can decrease considerably the willingness of team members to share knowledge within the team. The phenomenon of social loafing is more perceived in virtual teams than in face-to-face setting. The technology is found to foster this behavior because users are found to work in front of a screen where no one could supervise their activities. In addition, the playful environment of virtual world could also disperse users of their goal of use of these environments. Being together with others in a pleasant place virtually could make users waste their time chatting with people or maybe visiting new places.

The results reported from virtual worlds are witnessing the same impact of knowledge sharing on knowledge application as prior research on other technologies (Choi et al 2010). Knowledge sharing has been found very correlated to its application; usually a knowledge that is shared but not applied later has no importance. Virtual worlds' technology is found to be richer than a voice communication allowing more interactions between users (see chapter VI). Users could perform activities in team and be present together in the same place. However, in these virtual worlds all knowledge can be applied in these environments comparing to a face-to-face setting.

Workers on virtual worlds have confirmed the importance of applying shared knowledge by its significant impact on the individual performance. As knowledge application is mainly related to the individual level, it positively impacts the individual performance.

According to the literature, team performance was found to be different depending on the type of technology. In this study, we tried to explain this through the mediation of selected determinants. The deep sense of the features of the technology is influencing the attitude of users depending on how comfortable they are with the technology. It could make them more willing to interact with their teammates. The study of VW technology usage and more especially of group support system helps to deepen the understanding if the technology is supporting collaborative activities

within a team. The use in itself leads us to object manipulation and customization. Hence, we can understand dynamics related to IT impacts with its advanced features on the process of knowledge sharing and more generally on team performance. The good use and the mastering of the technology features are found to be crucial to the achievement of the goal behind the use of a certain technology.

Limitations

This study is not without limitations. First, this study is mainly related to 144 respondents using thirteen virtual worlds mainly Second Life. This may be explained by the fact that the respondent are professionals and they are working on these environments, so the selection is restricted to virtual worlds that are targeting serious purposes. We have also targeted two companies working inside virtual worlds.

Here also, we can highlight the importance of activities performed on virtual worlds as our respondents are teachers, software developers, accountants, etc. Our sample is very diversified regarding ages or educational levels of respondents. Usually, the new generation (Y) is more attracted by the use of new technologies in their workspace. This evolution in the use of advanced technologies could have an impact on the management style. Indeed, nowadays companies are choosing serious games for their trainings and advertisements.

This growing trend within organizations to use advanced information technologies to find and alternative to the physical means of face-to-face interactions. Virtual worlds are used because they are approaching real life experience in workspace and they are a low cost technology. However, little is provided by the literature regarding how these technologies may influence performance. Our study brings new insights about mediating determinants that have significant impact on team performance in virtual worlds setting. Hence, our findings have important implications on how to leverage these technologies for creating greater organizational value.

Our study shed the light on most important assets of virtual world technology and studies their impact on team collaboration. It focuses also on the individual level with the study of social loafing and its negative impact on collaboration. In addition, we focused also on individual performance as mediating the impact of knowledge application on team performance.

In summary, our study gathered a set of determinants from three different levels (technology, individual and collective) in the aim to give deeper understanding of the impact of the use of virtual worlds on team performance. This research has brought new insights about the mediating impact of social loafing on knowledge sharing. It brought explanations about the role of object manipulation and customization on the collaboration process and the group work support. In addition, this study designed a new measurement scale to the construct object manipulation. The scale enriches to the IS literature. Given the increased focus on virtual worlds to substitute face-to-face work, our findings will enhance the managerial adoption and use of these environments in workspace. This research brought a response to managers willing to use virtual worlds in their offices about the impact on team performance.

After the study of team collaboration in virtual worlds, we discovered the importance of determinants and their impact on team performance in a virtual world setting. In the next chapter, we propose the design of a serious game based on the findings about determinants. This game brings scenarios allowing to users to understand the specificities of the work on 3D virtual worlds.

CHAPTER VIII: DESIGN OF COLLABORATIVE SCENARIOS

"My work is a game, a very serious game."
Marurits Cornelis Escher[36] (1898-1972)

[36] Dutch graphic artist.

1. Introduction

After the studies presented above about virtual worlds, we have designed two research models as a first step in our methodological framework. Now we are moving to design science side which will involve the studied determinants. This chapter introduces a new collaborative serious game BestCollab. This game has the distinction of being based on solidarity and collaboration rather than individualism and competition. It puts forward team spirit over the individual one and serves to enhance collaboration skills for players. BestCollab aims to allow teammates to understand the importance of collaboration within a team. BestCollab is a scientific and methodological contribution which comes to cease with usual manners to train people. This game simplifies the data collection through questionnaires when we want to vary the control variables

Several serious games involve a collaborative dimension in their game play since players can play together to achieve team goals. As collaboration serves at synergizing collective efforts within a team in order to achieve the game's objectives. However, not all of them include learning elements aiming to make players getting collaboration skills and best practices. Few researches have focused on this topic such as (Toups et al. 2009; Toups et al. 2011a; Toups et al. 2011b), they were mainly centered on coordination between players (Song and Kleinman 1994) or on simulation for decision-making in (Toups et al. 2009; Toups et al. 2011a; Toups et al. 2011b). Here, there is a need of a new kind of game to facilitate the learning of collaboration among a team. According to the best of our knowledge, there is no game that is specific for that goal in project management field. This chapter is an attempt to address this gap and then to propose a new collaborative serious game BestCollab. It addresses these research questions: What are the objectives and the characteristics of this kind of game? How could be developed? What are the rules and specification steps? How can people learn using BestCollab?

This chapter positions this game in the space of existing games. We mobilized three learning theories in the aim to formulate game objectives, scoring system and rules. We followed a design science approach to deliver two versions of the game; namely one version targeting a project manager and the other version targeting team members. The game development follows six main steps of the development of usual

software. Finally, we present collaborative scenarios between teammates in the professional context of project management.

The remainder of this chapter is structured as follows. The next section presents a literature review discussing the characteristics of serious games. Then, we introduce our methodology to develop BestCollab. Next, we introduce the specification steps of the game and illustrate a scenario of application. Next section presents the evaluation process of BestCollab. The chapter concludes with a summary of the key limitations, and directions for future research.

2. The characteristics of a collaborative serious game

As serious games are a kind of digital games, they share the same characteristics with them:

- Serious games are played with a computer in accordance with specific rules (Zyda 2005).

- They use entertainment to further government or corporate serious objectives (Zyda 2005). According to Prensky (2001), games are a form of fun that provides a state of enjoyment and pleasure. They provide a win states and give us ego gratification (Prensky 2001). Besides, they are a form of play and allow the player to feel intensively and passionately involved. Finally, they are storytelling and provide playful scenarios.

- Serious games aim at transferring a serious content so they should be educational. Usually, these games have a set of learning goals which stimulate the motivation of the players (Gee 2008; Shaffer and Gee 2006; Squire 2005). They are highly interactive and allow a state of reacting and performing actions. In addition, they provide outcomes and feedbacks. They allow learning involvement and engagement. Thanks to their adaptability, they provide a state of flow when the player feels totally immersed in an action for its own sake (Paras and Bizzocchi 2005). They are adaptable and customizable to the player and provide immediate feedback. Consequently, games allow active discovery and develop new kinds of comprehension. Moreover, Paras and Bizzocchi (2005) argued that well designed games are a

potential learning vector and intrinsically motivating to players. According to them, "well-designed game mechanics can result in learning experiences which are intrinsically motivating". Games allow an engaging learning experience for players and should be used as part of a blended learning approach (Freitas and Oliver 2006; Klawe and Phillips 1995; Šisler and Brom 2008).

- Finally, serious games are challenging with the aim of avoiding boredom. According to Prensky (2001), games have conflicts, challenge and opposition in the aim to allow a state of motivation to achieve a goal. They have also problem-solving and simulate the player's creativity (Prensky 2001).

In this research, we aim at designing a collaborative game that encourages collaboration and helps players to learn its best practices. The resulting characteristics that define our game are: entertaining, educational, follows rules, challenging and collaborative. This game tries to simulate a workspace in a 3D virtual environment where time could be considered as the 4th dimension. Players are constrained with time and space to achieve a set of activities and collaborate together to finalize their projects.

3. Method

Given an identified business need, design science research tries to meet it through the building and evaluation of artifacts (Hevner et al. 2004). In this chapter, we are addressing the development of a new collaborative game BestCollab in the project management field. This research will use a design science approach to meet this business need. According to Hevner and colleagues (2004), this problem-solving paradigm allows researchers to meet unsolved problems by designing and developing artifacts. Later, these new artifacts will be evaluated regarding the utility they provided in responding to the business need (Hevner et al 2004). This approach is very suitable for the design and evaluation of a serious game by demonstrating its practical feasibility and utility through lab and field studies according to Hevner et al.'s (2004 p. 86) Design Evaluation Framework.

Design science propose four kinds of artifacts that could be produced (March and Smith 1995). In our research, the serious game's artifacts would be represented as follows:

First, *constructs* such as the set of characteristics describing the game. We have extracted five main characteristics from the literature: **entertaining, educational, follows rules, challenging and collaborative.**

Second, *models:* the class diagram including the game actors and their associations, and the use case diagrams describing the features proposed by the game to players, both managers and teammates. Third, *methods* which are the set of scenarios provided by the game play defining steps and provide guidance on how to run the game.

Finally, *instantiations* such as the collaborative game that is the software implementation of the above artifacts and provides the serious content of the game. The following sub-section details the different steps we follow to development.

Game development steps

The development of a serious game is based on five key steps which are the same found in a usual software development by (Royce 1970) adapted from (Boudier and Dambach 2010):

- Needs analysis: In this step, we have used the literature to identify and analyze game objectives. This step allows the verification of the adequacy between the game learning goals and its available content of the game.
- Proposal of the game design: In this step, the designer determines the type of the game (collaborative game), the graphics (3D), scenario (the story, actors, serious content, learning processes, etc.), rules (game play), interactions carrying learning, motivating elements (scoring, rewards), etc.
- Delivery of a first prototype: the development of the first prototype of the game.
- Evaluation of the game.

- Intermediate deliveries: This consists in iterative enhancements of the first game by correcting bugs.
- Free of bug final delivery: Delivering bug free version of the game.

The development of BestCollab can be summarized as follows. Based on the literature we identified the main research works on digital and serious games. We extracted fundamental characteristics of a collaborative serious game. Second, building on these characteristics and the theories application to our research, we have identified goals and rules of the game. Later, we have designed a set of scenarios that try to include the targeted pedagogy and taking into account the determinants identified in the previous studies. Third, we have followed the steps of game development to implement the game. The tool we used is Caspian learning platform called Thinkingworlds37 with the scripting language CScript. This game could be used with Iphone/Ipad.

4. The collaborative serious game BestCollab

Needs analysis

Learning theories and serious games

We have analyzed the three learning theories presented in the background section according to our game. The following table summarizes the results.

Theory	**Implementation**
Experiential Learning Theory **(Kolb 1984)**	• **Concrete Experience:** The players will be experiencing collaboration situations and try to manage their tasks execution regarding the whole project. They will help other team members by executing tasks collaboratively. • **Reflective Observation:** Players will understand the value of effective collaboration in enhancing individual performance. Optimizing actions in the game and interactivity are crucial to this step. Players will develop knowledge about team cohesion, team spirit, adjusting their interests with the

[37] http://www.thinkingworlds.com/

	team ones, etc. • **Abstract Conceptualization:** After every stage of the game, a kind of quiz is proposed to the players in the aim to assess the level of knowledge capitalization and if they have understood the goals of the current stage. • **Active Experimentation:** This stage of the learning process is supposed to be done after playing the game, when players decided to put into practice what they have learnt from it.
Social Cognitive Theory (Bandura 1986)	• **The development of cognitive social and behavioral competences:** In this game we are aiming to develop players' collaborative and social competences through collaborative situations pushing them to learn by doing how to overcome the difficulties of the game. • **The cultivation of people beliefs in their capabilities:** The game will encourage players to believe in the relevance of their own capabilities and the importance of collaborative skills to succeed a project. • **The enhancement of motivation through goal systems:** A process of motivation is developed basing on the scoring system, game rules, game levels and steps' goals.
Self-determination Theory **(Ryan and Deci 2000)**	**Needs**
	• **Competence evolving:** In the game, players want to feel the evolution from a game stage to another and they want to learn new tips and best practices. Scoring is another way to motivate the player. • **Relatedness:** Teammates will be highly interacting with other teammates, they will be caring for others' work and

	progress. • **Autonomy:** players are autonomous in many kinds of tasks such as choosing the project or scheduling workload.
	Type of motivation
	• **Intrinsic motivation:** This is a main feature of a game in general is to leverage entertainment. • **Extrinsic motivation:** In our game, we have set an extrinsically motivating scoring system based on three kinds of rewards. Serious goals of the game and the skills to learn from the game could be another means to motivate players.

Table 24 Application of the three learning theories in the case of BestCollab

BestCollab goals

After a careful analysis of the literature, we have deduced a list of goals to be implemented in BestCollab:

Goal	**Implementation**
Show interest to collaboration rather than competition	• Explained in the game rules.
Raising the spirit of collaboration in the collective work	• Communication between players. • Better rewards for collaborative actions.
Increase team cohesion	• Players are caring about other players' problems and suggesting help. • Adjust the interests of some over others. • Develop community spirit within the team. • Develop a collective sense of identity and group.
Better take	• Resolve a problem collaboratively.

advantage of collective intelligence	
Learn seriously to collaborate while having fun	• Resolve a serious problem. • Having fun when playing the game.
Share resources, risks and benefits	• Winning when helping to achieve other projects in time. • The better a player manages his/her project(s), the better (s)he helps others to manage their shared resources.

Table 25 Learning goals of the game

The findings of the experiments are integrated in the serious game in the aim to design a rich collaborative game, which takes into account the set of determinants, studied in the behavioral science side. Determinants could be measured inside the game through the scoring or it could be measured after playing the game though a questionnaire. The following table highlighted the presence of different determinants in the game:

Determinants	Implemented in the serious game	Remarks/Measured by
Co-presence	Multi player game with non player subjects helping the players (giving advices).	• Could be measured by asking the player about his/her capacity to feel the presence with other when playing. (Questionnaire)
Cognitive absorption	The game is designed to be interactive and challenging. In addition, this game is collaborative which generate more social interaction than an individual serious game.	• Could be measured by asking the player about his/her capacity to feel absorbed by the game and loose the time track. (Questionnaire)
VW technology usage	The use of the serious game to perform a set of collaborative scenarios.	• Serious games and virtual worlds are having close designs.

		• Expertise points and collaboration points • Questionnaire
Knowledge sharing	The players are supposed to share their knowledge and experience regarding the tasks of the project. They are able to communicate with each other via chat messages.	• Collaborative points. • Expertise points. • Could be measured by asking the player about his/her willingness to share knowledge (Questionnaire)
Knowledge application	The game aims at bring a learning by doing experience and making from the serious game a way to pass serious messages.	• Expertise points: Experience with the game (succeeding from one stage to the other). • Could be measured by asking the player about his/her ability to apply shared knowledge (Questionnaire).
Customization	The player is able to customize his/her avatar and his/her environment.	• Limited customization. • Expertise points. • Questionnaire
Object manipulation	The player is able to manipulate objects.	• Limited object manipulation. • Expertise points. • Questionnaire
Density	The player is interacting with his/her teammates and project manager.	• Collaborative points: The amount of different interactions. • Questionnaire
Social loafing	The behavior of player and his/her interaction with the game could help to identify social loafing.	• Delegated tasks exceed a threshold. • Wasting time. • Questionnaire
Individual performance	The game provides real time scoring reporting on expertise and budget points.	• Displayed scoring. • Questionnaire
Team performance	The game assesses the overall collaboration process.	• Team member satisfaction. • Project achievement.

		• Respect of deadlines. • Quality of the deliverables. • Hidden scoring. • Questionnaire

Table 26 Determinant involvement in the game

The game aims at making players evolve until forming a highly collaborative team by getting a maximum capability to effectively communicate, reach shared understanding, and adjust their tasks and behaviors to produce high quality outcomes. Table 25 summarizes the objectives of the game and the way they are implemented in the game. In this part, we describe the team members' game module (at the prototype advanced stage at this time) that was designed for helping players to develop collaboration skills and learn collaborative best practices through project management.

Proposal of the game design: Teammates version

The game offers different features and scenarios for collaboration between teammates sharing common projects and placed under the constraint of delivery of the final product. This project management problem may arise in any company mainly IT consulting companies. The game takes place in a company working five days per week. Three project managers manage five projects. They will choose their projects and the staff required for the project achievement. Teammates can be assigned to several projects at the same time (no more than three projects). In the same time, projects are divided on a set of activity and each activity has a load in man/day. In addition, an activity can be achieved by several teammates. Tasks could be executed in collaboration, by one team member or delegated to another team member depending on the priorities of the player. Each task has a level of expertise required which is defined by the number of time the player executed the same kind of task.

Teammates will try to collaborate by lending/borrowing budget and executing tasks together. Indeed, the main aim of the game is collaboration to make all projects advance and be achieved in time. Then, collaboration between project teammates will be a salient rewarding criterion on the individual level.

Use case diagrams and class diagram

Use case diagrams serves to describe user requirements regarding the game. Indeed, they allow describing the system from the user's point of view and defining the limits of the system and relations between the game and its environment. A use case is a specific way of using the system; it is a feature of the system. An actor is a person or a thing that interacts with the system. More specifically, an actor is a role played by a person or thing that interacts with the system. Same individual can belong to several players if it can play multiple roles. The overall use case diagram is provided in (Appendix 15). This diagram presents the main features provided by BestCollab for the game administrator, the project manager and teammates.

Scoring system

Scoring criteria

Teammates will be rewarded according to five criteria ordered from the most important to the least important:

- Collaboration with other teammates: checking the amount of collaboration between project managers (number of help given with or without negotiation). So, a team member will be rewarded if a project of another player is finished on time and with a good quality because (s)he contributed in this success.
- Timeliness: if the projects are delivered according to the schedule.
- Quality of the product: checking if there are no activities ignored or executed in an inadequate manner (without the level of expertise required).
- Relationship with project managers: checking if there are no dissatisfactions with managers (the team member refuse to execute a task or to work in over time).
- Exploitation of resources: checking if resources are optimally dispatched and managed during the game (no waste of time/budget/human resources).

Scoring categories

The scoring is divided into two categories:

- **Displayed points:** these points are related to the following scoring criteria: Timeliness, quality of the product, relationship with managers and exploitation of resources. They will be displayed for the staff member in the aim to encourage him/her. In this category, two sub-categories are identified:
  - Expertise points which are related to usual tasks and activities of players;
  - Budget points are related to unlocked goodies in the game and could be used to fund a project or skip a task;
- **Hidden points:** this score is related to collaboration score. The team member will not know it until the end of every stage of the game. It's directly related to how collaborative the player is (related with the first scoring criterion: collaboration with other teammates). The player will know from the beginning of the game that these points are the most valuable. Consequently, (s)he will try to collaborate as much as (s)he can and that's why they will remain hidden. Every collaborative action has its own score, for example a player may be rewarded when (s)he suggests a solution for another player but (s)he will be better rewarded when (s)he helps in collaboratively resolve the issue.

Game steps

Step 1

This step can be summarized in a set of instructions to explain the game rules. BestCollab will introduce the context of the company (number of projects, budgets, penalties and the role of collaboration between players). After that, the player will choose his/her game parameters such as the project on which (s)he wants to work. Projects are presented as follows:

- P1 (120 man/day to be achieved in two months)
- P2 (100 man/day to be achieved in 1 month)
- P3 (100 man/day to be achieved in 2 months)
- P4 (80 man/day to be achieved in 2 weeks)
- P5 (100 man/day to be achieved in 1 month)

A detailed class diagram of BestCollab is provided in appendix 13.

Step 2

The player chooses the profile of projects in order to apply for a job assignment basing on their coherence with the nature of the project. Some team members may be chosen to work in other projects with other managers. Team members could negotiate the choice of a project if any conflict occurs. This choice should be relevant because:

It may impact the quality of the product and thus influences the resulting score;

It may generate incoherence with other project managers' requirements and then disturbs the collaboration process;

Through this step, the players learn how to perform an optimum choice of an adequate project; they will learn to take into account the adequacy between tasks and their skills in the aim to guarantee a better quality of the project. In addition, they learn how to manage relational aspects mainly in negotiation. Players will learn to care about other players' satisfaction that leads to strengthening the collaboration process.

Step 3

The player will receive a set of tasks organized and scheduled in a Gantt diagram. This diagram should respect the project's constraints in term of resources. In this step, players should learn how to organize their schedules in the aim to respect the timeliness of the project.

Step 4

In this step, projects will be launched by the game. Players will learn how to collaborate together step by step. They should exploit every opportunity and ask for help when any problem occurs. They should suggest help to other players to evolve by executing tasks collaboratively to save time and reach higher level of expertise in a task. In addition, the game provides a real time interface describing project parameters and showing all notifications from other team members. Some suggestions could pop-up in front of the player to help him/her to manage a given situation.

Delivery of a first prototype

Project managers and Team members: Workspace management

Project managers could associate a task to a team member, then (s)he could negotiate this depending in his/her work load or priorities. A team member could suggest a meeting with his/her manager to discuss in chat the choice. The manager

could invite the team member to join another project or delete an invitation for a new task of the team member. In addition, managers could reward or penalize their project members.

Executing a task in collaboration between two team members

A task can be executed in collaboration between two or more team members. When a team member does not have the expertise level required for a task, (s)he can send a collaboration invitation to another team member to learn and evolve in his/her competence. In this case, the collaborative points will increase. However, expertise points of the performed task will be split on both of team members. A detailed sequence diagram is provided in the Appendix 14.

The scenario presented by this diagram is related to the execution of a task in collaboration between Pascal and John (two teammates). Pascal wants to share the execution of a task (code debugging) with someone else in the team who has at least (one) as a required expertise level. This means that the person who will be eligible to collaborate has done this task once before. After searching in the list of all teammates having this profile, Pascal sends an invitation to John. John accepts this invitation, and the collaboration process is launched. Before incrementing a Player's level in a task, the game must check the number of occurrences of this task. If this number is zero, the occurrences of this task will be incremented else the game will evolve the player to the next level of the task. (A task could be executed at least twice to attain a level; each task has four levels of expertise) After the execution of this task collaboratively, the game will reward them. The expertise score of both of them will be increased, while the collaboration score of John will be increased more than Pascal's one since John accepted the collaboration invitation of Pascal.

If the same task is executed only by Pascal (if he has the required level), he will earn expertise points only.

As the game is still under development, the last two steps of the development process (Royce 1970): (Intermediate deliveries and free of bug final delivery) aren't achieved yet. We are in the evaluation step presented in the following section.

Proposal of the game design: Project managers' version

The game offers different scenarios for collaboration between IT project managers sharing common resources (budget/staff) and placed under the constraint of delivery of the final product. This project management problem may arise in any company mainly IT consulting companies. The game takes place in a company working five days per week. Three project managers Maya, Yannis and Adam will play together to manage five projects. They will choose their projects and the staff required for the project achievement. As the number of engineers is twenty five, project managers will share human resources and budgets under the constraints to finish in time. Engineers can be assigned to several projects at the same time (no more than three projects). In the same time, projects are divided on a set of activity and each activity has a load in man/day. In addition, an activity can be achieved by several engineers.

Project managers will try to collaborate together by lending/borrowing budget and staff members. Indeed, the main aim of the game is the collaboration to make all projects advance and be achieved in time. Then, collaboration between project managers will be a salient rewarding criterion on the individual level.

Scoring system

Scoring criteria

Players will be rewarded according to five criteria ordered from the most important to the least important:

- Collaboration with other project managers: Checking the amount of collaboration between project managers (number of help given with or without negotiation). So a project manager will be rewarded if a project of another player is finished on time and with a good quality because (s)he contributed in this success.

- Timeliness: if the projects are delivered according to the schedule.

- Quality of the product: Checking if there are no activities ignored or given to inadequate staff members.

- Relationship with engineers: Checking if there are no dissatisfactions between staff members such as working on inadequate tasks or working in weekends.

- Exploitation of resources: Checking if resources are optimally dispatched and managed during the game (no waste of time/budget/human resources and minimum repeated tasks).

Scoring categories

The scoring is divided into two categories:

- **Displayed points:** these points are related to the following scoring criteria: Timeliness, quality of the product, relationship with engineers and exploitation of resources. They will be displayed for the player in the aim to encourage him/her.
- **Hidden points:** This score is hidden. The player will not know it until the end of the game. It's directly related to how collaborative the player is (related with the first scoring criterion: collaboration with other project managers). The player will know from the beginning of the game that these points are the most valuable. Consequently, (s)he will try to collaborate as much as (s)he can and that's why they will remain hidden. Every collaborative action has its own score, for example a player may be rewarded when (s)he suggests a solution for another player but (s)he will be better rewarded when (s)he lends a resource for him/her.

Game steps

Step 1

This step can be summarized in a set of instructions to explain the game rules. The game will introduce the context of the company (number of projects, budgets, penalties and the role of collaboration between players). After that, the player will choose his/her game parameters such as the project manager that (s)he wants to play (Maya, Yannis or Adam). Projects and managers are presented as follows:

- Maya manages two projects: P1 (120 man/day to be achieved in two months) and P2 (100 man/day to be achieved in 1 month)
- Yannis manages P3 (100 man/day to be achieved in 2 months)
- Adam manages P4 (80 man/day to be achieved in 2 weeks) and P5 (100 man/day to be achieved in 1 month)

Step 2

The player chooses the profile of engineers to recruit basing on their coherence with the nature of the project. Some engineers may be chosen to work in other projects with other managers. According to his/her choice, other project managers could react mainly when the engineers' number is high or the engineers' skills are incoherent with the project. This choice should be relevant because:

- It impacts the quality of the product and then influences the resulting score;
- It may generate incoherence with other project managers' requirements and then disturbs the collaboration process;

Through this step, the players learn how to perform an optimum choice of resources; they will learn to take into account the adequacy between tasks and staff skills in the aim to guarantee a better quality of the project. In addition, they learn how to manage relational aspects mainly in negotiation. Players will learn to care about other players' satisfaction which leads to strengthen the collaboration process.

Step 3

The player will prepare a Gantt diagram and dispatches tasks on different staff members. This diagram should respect the project's constraints in term of resources. Players should minimize risks by doing a realistic estimation of the project requirements. In this step, players should learn how to organize their schedules in the aim to respect the timeliness of the project.

Step 4

In this step, players will launch their projects and learn how to collaborate together. They should exploit every opportunity and ask for help when there is insufficiency in resources. They should suggest help to other players when there are some resources' availabilities. In addition, they should identify repetitive tasks and minimize them to save time. The game provides a real time interface describing all project(s) parameters and showing all notifications. Some suggestions could pop-up in front of the player to help him/her to manage a given situation.

Delivery of a first prototype: Project manager's version

The player chooses Adam as project manager. He will manage two projects (P4 and P5). After, the player will choose a number of engineers (or teammates/shared resources). We assumed that the number is 11. Knowing the total number of engineers (25), the other project managers will react against this choice because it will lead to a delay on their projects' execution (human resource insufficiency). The game will alert Adam about the dissatisfaction of Yannis and Maya, and it will propose 3 options:

- Defending the choice;
- Continue with the same number, and promise to collaborate later;
- Reduce the number of engineers.

Figure 13 Screen shot of option provided by the game

Adam chooses to negotiate and reduce the number of engineers to 10. Other project managers will know about this choice through the notifications sent by the game. After this negotiation, the player will assign a number of engineers on each

project (4 and 5) and prepare his/her schedule. We assume that he chose five engineers for each project. He will launch his project and supervise his/her advancement. He may respond to some help from other project manager or try to optimize the Gantt diagram. In the beginning of the game, the situation of Adam was:

- P4 (80 man/day to be achieved in 3 weeks)
- P5 (100 man/day to be achieved in 1 month)

One week later, the situation becomes:

- P4 (70 man/day to be achieved in 2 weeks)
- P5 (75 man/day to be achieved in 3 weeks)

We assume that the game send him/her a notification about a human resource insufficiency. At this stage, the game proposes him to choose between two options:

- Ask for help from other project managers;
- Continue.

For example, the player receives the answer: "Sorry, I can't". The project managers need their resources (see Figure 14). In this case, the game will help him to choose between four options (a simple of screen shot in Figure 13):

- Maintain the same distribution of teams and continue;
- Maintain the same distribution of teams and increase the number of working days;
- Change the distribution of engineers on projects;
- Continue negotiations with other project managers;

We assume that the player chooses to change the distribution of engineers between his two projects. He will assign 7 engineers for P4 and 3 engineers for P5. After the second week, the situation will change as follows:

- P4 (35 man/day to be achieved in 1 week)

- P5 (60 man/day to be achieved in 2 weeks)

The player may choose to employ a number of engineers over the weekend to avoid unpleasant surprises at the end of the project. By opting for this choice, he will be slightly sanctioned (dissatisfaction of engineers and decreasing of their motivation). Finally, he found that he has an available engineer, so he will suggest help to other project manager. In this scenario, we assumed that Maya accepted this suggestion (Figure 16).

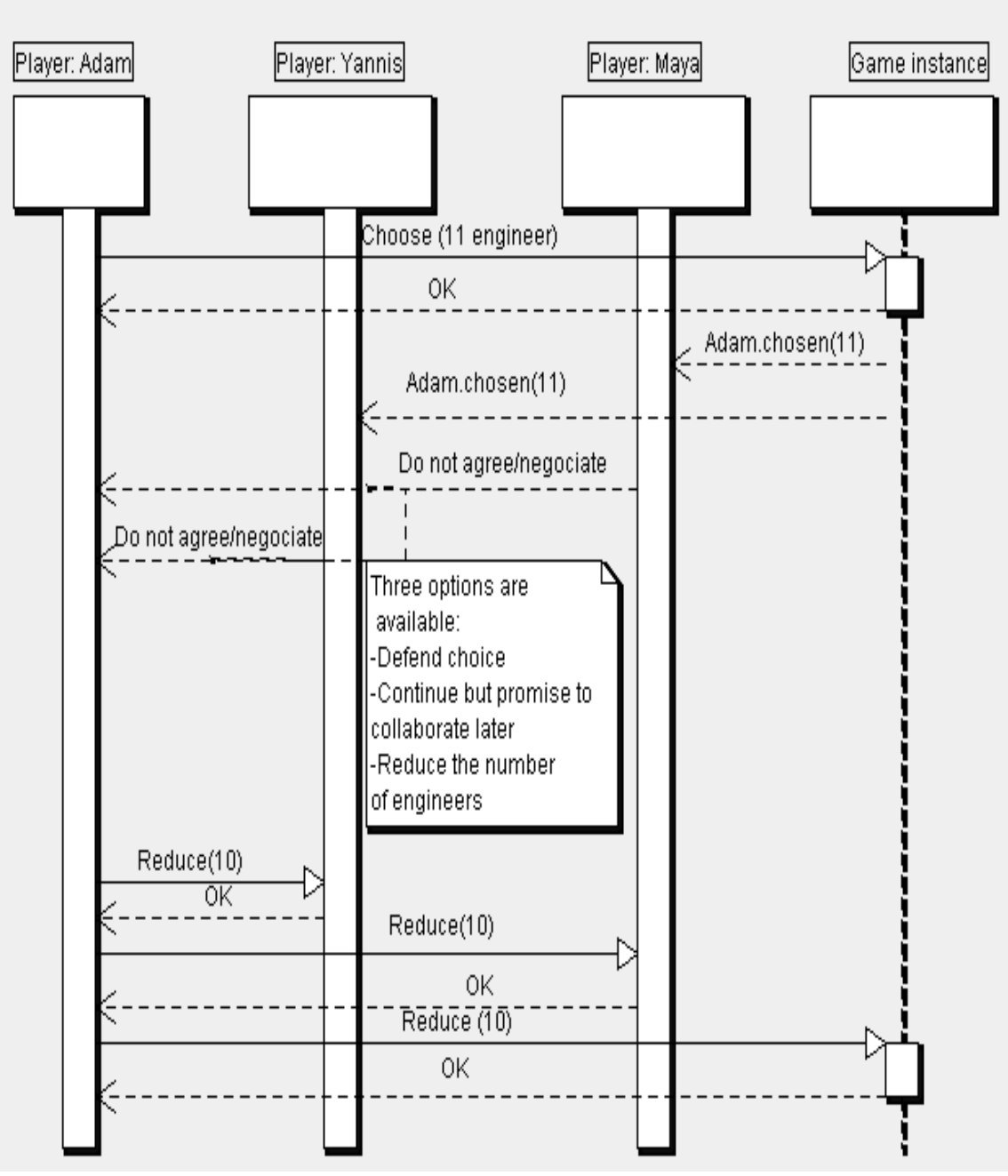


Figure 14 Scenario of choosing engineers (1)

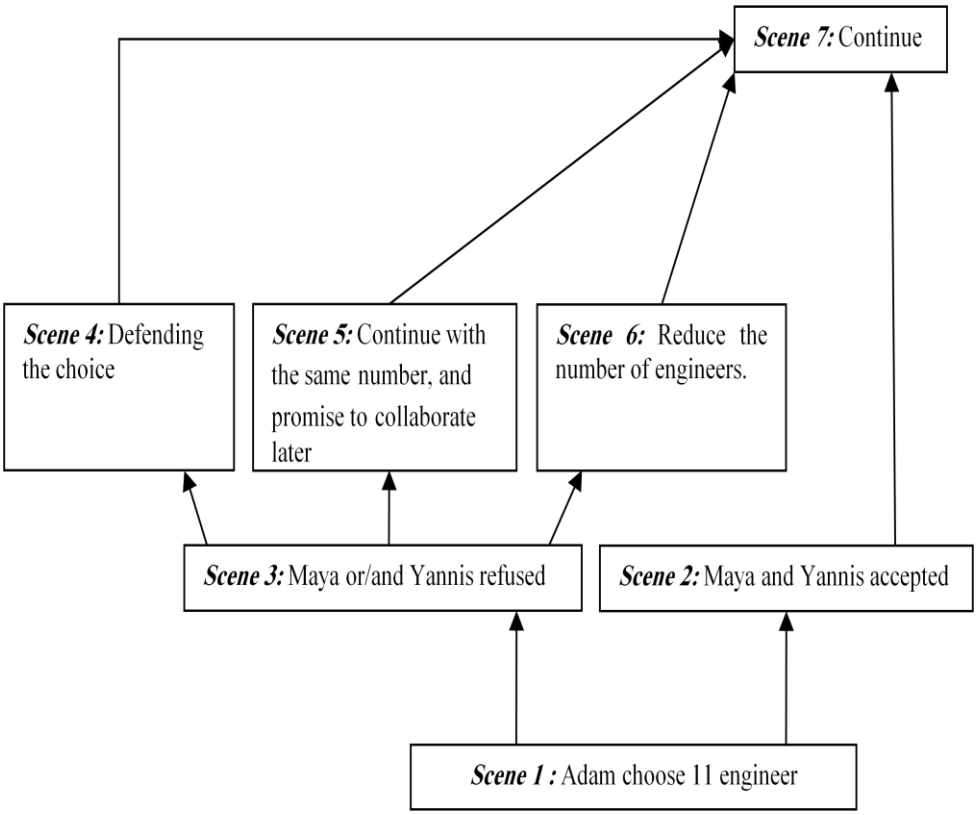


Figure 15 Scenario of choosing engineers (2)

Game specification

Use case scenarios

In the aim to deepen the understanding of the current game features, we will present a detailed modeling. These functionalities are presented as UML (Unified Modeling Language) diagrams.

Use case diagrams

Use case diagrams serves to describe users' requirements regarding the game. Indeed, they allow describing the system from the user's point of view and defining the limits of the system and relations between the system and its environment. A use case is a specific way of using the system; it is a feature of the system. An actor is a person or thing that interacts with the system. More specifically, an actor is a role played by a person or thing that interacts with the system. Same individual can belong

to several players if it can play multiple roles. This game involves two kinds of actors: Project Manager and Project member. The specifications of the game will use case diagrams are given in Appendix 18.

Appendix 16 and 17 provide two screen shot from thinking worlds scenes and screen shots.

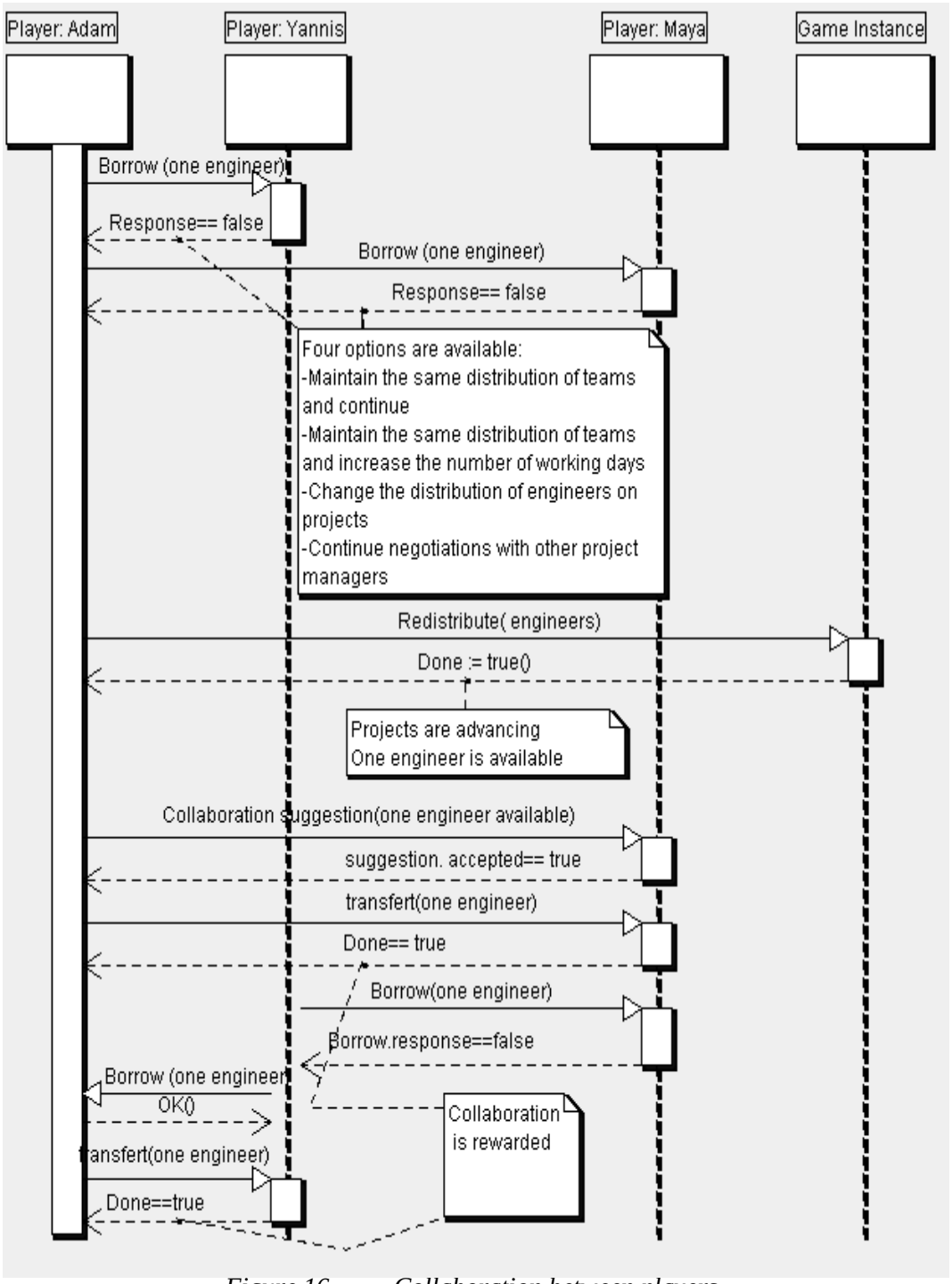


Figure 16 Collaboration between players

Evaluation of the game prototype

We plan assessing on the ground the game from using (Scapin and Bastien 1997) evaluation approach.

This approach provides 8 criteria and a total number of 20 sub-criteria in order to evaluate ergonomics of the game, such as the compatibility between the user characteristics (memory, competences, age, requirements, etc.) and the tasks provided by the game, the immediacy of feedback, incitation, guidance, etc.

According to (Pries-Heje and Baskerville 2008) the evaluation could be naturalistic (case studies) or artificial (lab experiment). In this research, we plan to conduct a lab experiment with management graduate students who are familiar with serious games and 3D virtual environments. Participants have already a good background on project management. They should discover the game before the experiment.

100 Students will use the game for a period of 20 minutes through a specific scenario. Later, they will respond to a qualitative questionnaire about satisfaction with the game and learning outcomes. Students will be asked to mention any problems through the game use and can make recommendations (difficulties to understand a game level, bugs, fuzzy game rules or scoring issues). Finally, following the iterative cycle of Design science research, findings will be integrated to refine the game.

Design validation and implications

According to Hevner and colleagues (2004, p 82), evaluation is crucial to an artifact design. To check the validity of our artifact, the seven guidelines of the Design Evaluation Framework of Hevner et al. (2004) should be respected. In this chapter, we are following these seven guidelines. In order to produce new artifacts and add them as applicable knowledge to the knowledge base (see Framework for Information Systems Research by (Hevner et al 2004, p. 80).

Guideline	Implementation
Guideline 1: Design as an	We are developing a game and its application showing gradually how to solve a specific problem related to learning

artifact	goals.
Guideline 2: the relevance of the problem	This game fulfills a business need as expressed by professionals as a means to learn team collaboration and increase productivity.
Guideline 3: Evaluation of design	The game is under development, it has not been evaluated. In the next sub-section the evaluation game process that we will conduct in order to ex ante assess the game. An ex post evaluation should be done as well.
Guideline 4: Research Contributions	Our literature review showed that such serious game in project management is needed.
Guideline 5: Rigorous research	The development has been rigorously defined using a combination of research methods including a literature review, mobilizing learning theories and following design steps.
Guideline 6: Design as a research process	We have respected a rigorous research process starting from literature review and learning theories. We have followed the six steps of software design.
Guideline 7: Communication Research	Our results are and will be communicated in two steps: First, the method and initial experiments are presented through publications to other researchers; we want them to help us to consolidate and expand the game and its application. Moreover, project team members and managers could use the game and provide us feedbacks and recommendations for its future improvement.

Table 27 The seven guidelines for Design Science

5. Conclusion

In this chapter we report on the design of a new collaborative serious game aiming to improve team collaboration and help team members to learn how to collaborate effectively. The game was developed following a design science approach to meet a business need expressed in project management within IT consulting companies where project managers are regularly confronted to common shared resources and collaboration challenges. Our contribution is both theoretical and practical as we propose a model, application scenarios and a supporting tool (under development). We are enhancing iteratively the current version (for the two modules proposed for mangers and teammates) by removing bugs until having a bug free version.

We followed a V cycle of software development as it allows an iterative process of correction and refinement of the game. The specifications and the design of the game started in the middle of this thesis and were running in parallel with the behavioral science studies. In this research, we didn't follow the IMS-Learning Design[38] to model our learning processes.

In this game we used the determinants identified in the studies above. The implication of the determinants could be perceived by actions performed by the users when playing the game such as knowledge sharing or social loafing, etc. Or these determinants could be perceived by the responses of the users after playing with it such as co presence of cognitive absorption.

In this thesis, we present a prototype of a collaborative serious game designed basing on the findings of the studies presented above. However, we achieved the specifications but the development is still not finished yet. In this game, we started from a managerial study and exploit its findings by designing a new game.

However, there are some limitations related to this work: evaluation of the game and evaluation of the design research process. In order to complete the Design Science Evaluation Framework, lab experiments and field studies have to be conducted in the aim to evaluate the game artifacts and to further enhance them. Later

[38] Instructional Management System Learning Design
http://www.imsglobal.org/learningdesign/index.html

and after the first lab experiment, the game will be presented to and tested with professionals in the project management field.

CHAPTER IX: SUMMARY OF RESULTS

1. Introduction

This research tries to respond to a research gap and a business need. Indeed, we are trying to fill into the gap of identifying, categorizing and studying relevant determinants characterizing team collaboration in 3D virtual worlds in the aim to understand the impact on performance. In addition, we are trying to meet a business need of companies about the use of virtual worlds in workplace by providing a set of best practices. In this chapter, we presented the summary of the results brought by this research. We start responding to the research questions and analyzing the overall results.

2. Research questions

The main objective of this research is to study the impact of the use of 3D virtual worlds on team collaboration and performance. We are trying to respond to the research question:

How can we use virtual worlds to enhance team performance?

We divided it into four sub-questions as follow:

1. Which are determinants of team collaboration in 3D virtual environments?

We have identified determinants of team collaboration in our literature review. Then, these results have been supported by the quantitative studies of virtual worlds.

- **Co-presence:**

The study of co-presence in our first quantitative study shows that this construct has a significant positive impact on team performance. It has been found to foster team collaboration by impacting cognitive absorption and density. The research argues that sense of co-presence should be sufficient enough in teams using virtual environments to realize greater impacts on performance. Thus, if team members are able to realize a state of greater flow, immersion, control, they are able to perform better. Indeed, social presence theory predicted that media differ in their communications characteristics based on the capacity of the medium to support cue system. Media richness theory posits that rich media are able to carry more information and then to facilitate

communication. As much as the medium is rich people are feeling the co presence with others. Indeed, richer media are able to grant a better space to team collaboration and this result is supporting Martins and colleagues (2004) insights about virtual teams. Co presence could be more significant in 3D virtual worlds thanks to the ludic design of these environments. People are seeing the avatars of their teammates and sharing verbal and non-verbal communications. The richness of these media is having important effect on making users feeling the being together with others and sharing more information. In addition, 3D virtual worlds grant synchronous and asynchronous communications. According to the media synchronicity theory, communications will be enhanced when the synchronicity a given medium can support appropriately matches the synchronicity that a communication process requires. Indeed, high richness and synchronicity of communications provided by 3D virtual worlds are salient arguments to make the co-presence more significant comparing to other communication tools like Skype. 3D virtual worlds are granting 3D environment more interactive where avatars can surf and join their teammates in different places by walking or teleporting which is not provided by lean communication tools. Finally, a greater sense of co presence may influence the nature of involvement and help team members to achieve greater cognitive absorption in the task and more engagement in their workspace. Our research supports that greater co presence enhances the interaction between teammates and fosters team performance. In the same time, participants are from young generation who are very familiar with video games maybe this fact makes them more at ease with Second life comparing to Skype. They are mastering the use of Skype and feel very excited when using Second Life.

This determinant could be measured when using the game through a questionnaire. Users should respond to this questionnaire after playing with the game.

- **Cognitive absorption:**

This construct has been found to impact significantly and positively team performance. The study of cognitive absorption permits us to understand the dynamics related to VW impact on team collaboration. Indeed, it impacts positively the sense of presence within the team. It is a fostering determinant since it rises the sense of engagement with the task. According to Agarwal and Karahanna (2000), perceived media richness of a certain technology is positively and significantly related to the

cognitive engagement for which derives the concept of cognitive absorption. The comparison between Second life and Skype supports that in 3D virtual worlds cognitive absorption is more significant. Users are feeling more engaged with the tasks they are performing. Indeed, the 3D design of these environments and their high richness could be the main cause behind great cognitive absorption. Users are loosing the track of time and feeling totally immersed in the space. They are feeling pleasure and enjoyment when performing the interaction. They are feeling cognitive curiosity and controlling their interactions. Indeed, these results meet the finding of Burton-Jones and Straub (2006) who support that cognitive absorption is fostering team performance. It was also found that cognitive absorption is a key driver to adapatative intention to use 3D virtual worlds for workspace collaboration (Chandra et al, 2012). However, cognitive absorption could have a negative effect by distracting users from their goal behind using 3D virtual worlds in workspace which will make them waste their time and loose concentration on their own work (mainly social Networking). So, users must create a separate account for Professional use in the aim to avoid any interaction with their social network when working. This determinant could be measured when using the game through a questionnaire. Users should respond to this questionnaire after playing with the game.

- **VW technology usage (GSS usage):**

GSS usage has been found to significantly impact knowledge sharing by the mediation of customization and object manipulation. More specifically, virtual worlds have been found to support group collaboration activities. Indeed, group support system is more influential than decision support system or information report system. This result is coherent with the study since the sample is using 3D virtual worlds to perform collaborative activities with their teammates. The impact of group support system usage on knowledge sharing has been found to be moderated by customization and object manipulation. First, customization is considered as a key feature of 3D virtual worlds since it permits the users to shape their own avatar and their environments (Suh et al 2011) which make them more at ease with the technology and willing to share knowledge with their collaborators. Customization is found to give users the feeling of appropriation of the avatar and the space which could enhance their attachment to the technology and enhance the quality of interaction with other teammates. This result

meet Suh and colleagues (2011) findings which support that customization has an effect of the behavior of avatars inside the virtual environment. Second, object manipulation is considered like a salient technological feature of 3D virtual worlds. It makes avatars approach real life and feel more excited about the technology. This feature is making virtual world richer media since it allows users to perform new tasks that are not supported by other technology such as simulation. Users could present a virtual object and manipulate it in front of other avatars which facilitate the understanding and knowledge sharing. In addition, avatars could perform some tasks in collaboration touching and manipulating together their space and objects which fosters the Learning-by-doing experience in these spaces. Being able to touch and manipulate objects together could have an influence on fostering social interaction between avatars.

- **Knowledge sharing:**

According to the literature of virtual teams, knowledge sharing is a key construct which fosters team collaboration and positively impacts performance. The same result is confirmed through our research in virtual worlds. Knowledge sharing is influenced by the richness of the medium and its capacity to support cue system. The capacity of 3D virtual worlds to support different types of communications could enhance knowledge sharing inside the team. The construct could be impacted by the experience of the user with the technology since users should be able to know the capacity of the medium and the appropriate communication tool to use depending on the context. According to the literature of virtual teams, the usage of information technology to support knowledge sharing leads to more effective knowledge sharing in teams (Choi et al 2010). According to Griffith et al 2003, the use of technology could foster the efficiency of team work. Mainly, it could enhance knowledge sharing if the technology is rich and synchronous since the communications are more interactive and able to support more cues. The literature about knowledge sharing argues that it is a key success factor for collaboration (Grant 1996). Indeed, in our research this finding is also supported as knowledge sharing has been found as a facilitator determinant of team collaboration. According to Wang and Noe (2010), knowledge sharing could be influenced by the type of technology used in the workspace and by the team members' behavior. This finding is supported by our research as knowledge sharing has been

found to be negatively and significantly impacted by social loafing. In addition, the type of technology (3D virtual worlds) has an influence since we found that the impact of usage of technology on knowledge sharing is moderated by the effect of two features of the 3D virtual world technology. Knowledge sharing is influenced by customization and object manipulation in workspace.

- **Knowledge application:**

This construct is found to positively impact individual performance and foster team collaboration. Knowledge application is considered as a key individual capability and the crux of knowledge management. In fact, even if knowledge sharing is considered as salient to the organizational development, it is not sufficient to enhance the performance. Indeed, knowledge must be not only shared by also effectively applied in the appropriate context. In our study, it has been found to have a positive effect on individual performance and team performance. Indeed, if the technology allows its users to apply the shared knowledge, this could foster the apprehension of new skills and the enhancement of individual and team performance. This result meets the literature (theory of technology task fit) which posits that IT usage could positively impact individual performance if the capabilities of the technology are matching with users' tasks. In addition, the experience with the technology could have an impact on the manner the users apply knowledge and it could impact the individual performance. Regarding the capacities of 3D virtual worlds, the ability to share and apply knowledge is more important than when using other types of technology as in 3D virtual worlds users could learn and apply new skills by doing them inside the virtual space.

- **Customization:**

According to the literature, customization is found to bring more ease with the avatar and the environment which has an impact on the engagement process with the technology (Suh et al 2011). Our research confirmed this and explained it via the mediating positive effect of customization between group support system and knowledge sharing. As much as users as at ease with their work environment, they will be more engaged and enthusiastic. According to Ducheneaut and colleagues (2009), designers of 3D virtual worlds should take customization into account when they are

developing new environments because it is a salient feature which could impact the use and the adoption of the technology. Customization provides the users with the ability to appropriate their workplace and to feel more comfortable with the technology. It has been also found to impact the users' behavior inside the virtual environment and to influence the manner team members are interacting together. Indeed, the appearance of the avatar should be respectful to the working context and each user should respect others when customizing his/her own shape. This could enhance to positive effect of customization and inhibit any conflicts generated from the miss respectful appearance. In addition, the proteus effect confirms the impact of avatars' appearance on the behavior of users. Customization could have a positive effect on knowledge sharing but it could also be with a negative effect according to Yee et al 2006.

- **Object manipulation:**

As a unique asset of virtual worlds, this construct is found to foster team collaboration by approaching the real world and making from virtual worlds a very enthusiastic experience. It has a positive significant impact as a mediating construct between group support system and knowledge sharing. It fosters the collaborative activities by adding more vividness the interaction between avatars (Davis et al 2009). This determinant depends on the tasks performed in the virtual space and the extent to which these tasks require flexible manipulations of objects. This determinant has found to enhance knowledge sharing when performing collaborative tasks. This result could be explained as object manipulation enhances the level of interaction between teammates and can foster the learning by doing experience inside the virtual environment. Indeed, higher level of interaction has a positive effect on knowledge sharing. Object manipulation is approaching real experience and makes 3D virtual worlds a metaphor of real life (Ruddle et al, 2002). Even it enhances the sense of being there as it fosters social interaction. Object manipulation could be more relevant when it is related to simulations, however in this research we are not interested in the notion of simulation. Indeed, simulation is related mainly on the set of activities to be performed on the virtual environment.

- **Density:**

According to the literature of virtual teams, this determinant is found to be influential on dynamics of IT impact on collaboration. Our quantitative study confirms the inhibiting impact of this construct and it measures it negative impact on team performance. Indeed, it weakens the cognitive absorption and makes the sense of presence fuzzy. This element is found have less impact on virtual worlds comparing to a voice communication tool such as Skype. Indeed, the 3D design of virtual worlds gives them more flexibility is social interaction between teammates. The immersive spaces give teammates the ability to meet in the same space and to share more comparing to Skype. In this latter, teammates are constrained to not exceed 6 or 7 to communicate together in the same communication with the difficulty to follow the information. Users can not have the freedom to present slides with an interactive manner, they can only share one screen and follow the voice of the presenter. They can not share the screen and see the presenter in the same time. That's why the negative impact of density is found to be more significant in Skype comparing to Second Life. The network interactions between teammates are fostering the cognitive absorption but when they become larger this impact will negatively impact the cognitive absorption. When several interactions occur simultaneously the communication becomes fuzzy as there will be greater increase of information and lack of relevance of exchange information in the interactions.

- **Social loafing:**

This construct has been found to be more consequent in virtual teams and having negative influence on team collaboration. It has been found to be a key cause of the drop of productivity. In the context of virtual world, this negative impact was shown by a significant impact on knowledge sharing within the team. Social loafing could also be perceived in interactive spaces such as virtual worlds. The literature about social loafing supports that this phenomenon is highly perceived in online groups as there is a lack of control on the presence of people in front of their personal computers. As virtual worlds are interactive spaces, we thought that the characteristics of these environments could diminish the impact of social loafing, however, this phenomenon is perceived and has a significant negative effect on knowledge sharing and on team performance. In the context, of virtual worlds, avatars could seem to be present inside the workplace even if the user is not following with his/her teammates. Users can be

distracted to do other activities in the virtual spaces while they are considered to be working. Although, in the context of executing tasks with other teammates, the users could not escape to his/her work as the interaction with others is rich and synchronous.

In Figure 17, we provide the summary of the identified determinants, their different categories and their respective effect on team collaboration. The plus means that the determinant is fostering team collaboration while the minus is related to the inhibiting effect of the determinant. The determinants have been found to belong to three different categories.

- **Individual characters:** this category gathers determinants related to the user such as social loafing, knowledge application, etc.
- **Collective characters:** this category gathers determinants occurring when the user is working in team such as knowledge sharing, density, etc.
- **Technology features:** this category gathers determinants related to the capacity of the technology such as customization and object manipulation.

We noticed that both the individual and the collective characters contain an inhibitor. The technological level didn't have any determinant that is inhibiting collaboration because the only determinants we studied have been found to impact positively team collaboration.

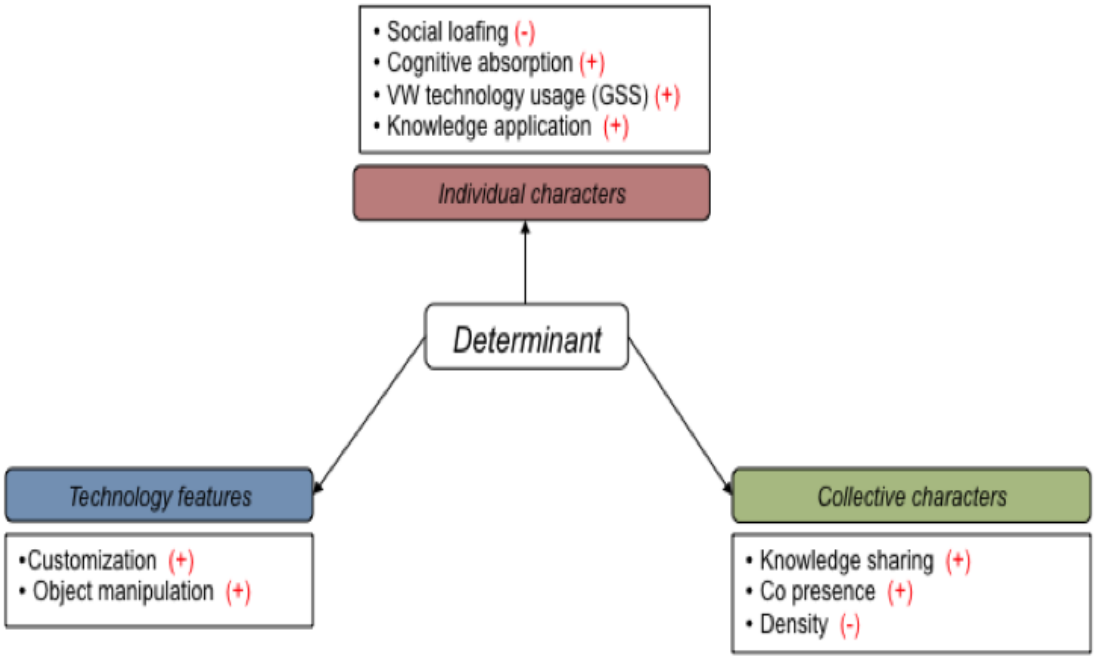


Figure 17 Summary of the results about determinants

Determinants can be examined from another angel, user centered view. We can classify them into three levels of interaction. Starting from human being, we identify the human behavior. This first level highlights the importance of the human behavior in the collaborative process. Since, for instance, social loafing has been found to negatively team performance.

Then, as team members are working using technology (3D virtual worlds), we identified a level of human-computer interaction. This level contains two types of determinants. Determinants related to the use of the technology such as knowledge application, object manipulation or customization or technology usage. In addition to determinant related to the influence of technology usage on human being such as cognitive absorption. Finally, a third level of team collaboration appears when people are collaborating.

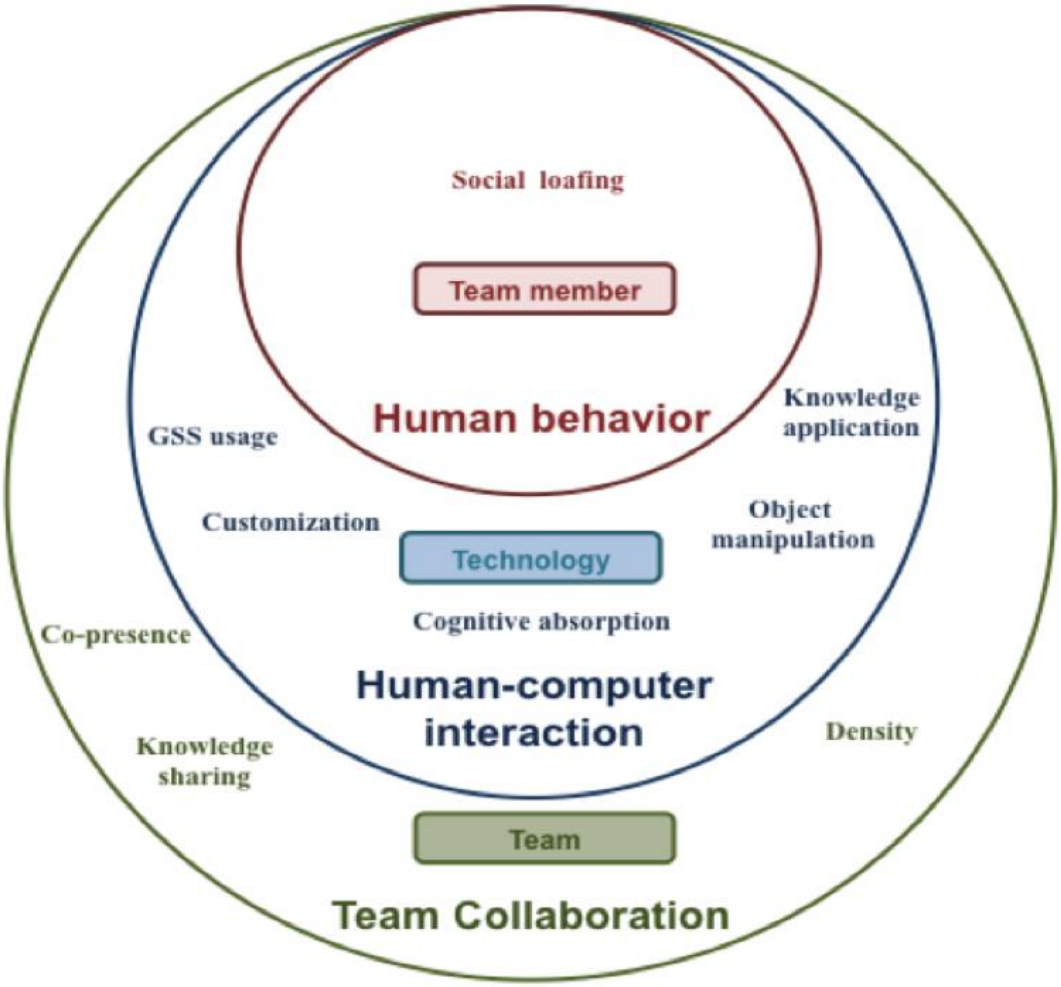


Figure 18 Determinants classification into three levels of interaction

2. Is there any difference between 3D virtual worlds and other media to support collaborative activities ?

The choice of the technology is found to be crucial to team collaboration as the richness and the synchronicity of the medium have a determinant effect on the quality of information. Indeed, according to the literature on virtual teams, the technological perspective argued that an effective collaboration is a collaboration that enables an efficient tasks execution and leads a team to achieve its objectives. Thus, this perspective seeks to enhance collaboration and reach efficiency. In this context, team collaboration is based mainly on the choice of information and communication technologies used by the team. Three streams co-exist in this approach and suggest three criteria for selecting technologies to effectively perform tasks. The first stream is influenced by the theory of media richness (Daft and Lengel 1986) which emphasizes the link between information type conveyed by the media and tasks' achievement. This stream considers technologies as the essential support for collaboration and classifies them according to their richness and therefore their ability to afford the use of a variety of languages, to provide a high degree of personalization and to perform multiple exchanges through various channels of communication (written information, verbal and physical). Virtual worlds are considered as richer than voice communication media but could not substitute face-to-face physical presence. According to our experiments, the richness of virtual world permits them the achieve tasks that could not be done with other technology such as simulations using object manipulation. However, they stay in the incapacity to reproduce the real world and the physical cues and body language. In spite of the non-verbal communication provided by these environments, still many conflicts occurring due to the lack of physical presence.

Virtual worlds are more interesting to maintain better performance of the collaboration comparing to Skype. This result is due to the importance of the virtual co-presence and cognitive absorption in virtual worlds (more engagement in the tasks) and the reduction of negative effects due to the density of interactions. This can be discussed if the co-cognitive absorption and caused a distraction from the goals of the use of virtual worlds. Moreover, once the number of team members decreases, the results may vary.

The second research stream is influenced by the theory of media synchronicity (Dennis and Kinney 1998) and emphasizes the link between modes of information exchange offered by technology and tasks' achievement. This theory assumes that the media should cover five features, namely: the immediate return (immediacy of feedback) and therefore the ability of media to ensure rapid bidirectional communication, a variety of symbols (Symbol Variety) relative to all the possibilities that the media offers to codify and represent the information; parallelism (Parallelism), which is reflected in the number of synchronous conversations that can occur simultaneously; regulation (Rehearsability) which is the fact that media allows an actor to reformulate or adjust his message when it is about to be sent and finally test reprocessing (Reprocessability) which means that actors can reconsider the archived messages. Virtual worlds integrate both synchronous communication (voice, avatar presence) and asynchronous communication (private messages).

Meyer and colleagues (2009) suggested that an effective collaboration is probable in these environments under the respect of synchronicity of the collaboration. While Schouten and colleagues (2010) argued that thanks to the synchronicity of VWs, the shared environment and avatar-based interaction lead to aiding processes convergence in decision-making tasks, leading to increase the shared understanding between different members.

Finally, the third stream which is the most emerging, it is based on knowledge management researches and links between the terms of information structuring offered by ICT[39] and tasks' achievement. Our experiments studied the impact of knowledge sharing and application on team performance. The results argue that knowledge management dynamics is very crucial to succeed collaboration. This could be explained by the importance of the knowledge as a crucial organizational resource and also by the role of knowledge sharing as a key success feature of the collaboration. The literature supports the importance and the choice of the technology to support knowledge sharing. Our findings meet these results from the literature and argue that the characteristics of the medium have a strong effect on the knowledge sharing and application.

[39] Information Communication Technology.

3. What is impact of the specific characteristics of 3D virtual worlds on the individual and the collective performance?

Our two quantitative studies have shown the impact of the set of chosen determinants. Indeed, these constructs are influencing each other and impacting the overall process of collaboration. The understanding of the dynamics of the IT impact on team collaboration in both studies shed the light on the extent to which these determinants could impact the performance of the team. The studies highlight the impact of the technology assets and the extent to which users are at ease with it. The example of customization and object manipulation were witnessing this impact by the influence on knowledge sharing. Besides, the importance of human attitude has also a determinant effect to make the collaboration successful. For instance, full interaction between teammates could make the communication fuzzy and complicated in the same time the presence of loafers within the team will make the productivity on drop. In addition, the smooth knowledge sharing and the ability to apply this shared knowledge are impacting the collaboration process on the individual and the collective level.

In this research we argue that co-presence is a fostering element to better performance, as users will feel warmth and inter-personal relationships with their teammates. As reported from the theory of social presence, media allowing greater feeling of presence will lead to better social interaction.

The capabilities of 3D virtual worlds have been found to foster the learning by doing experience within a team which encourages knowledge sharing and application. In addition, the richness and the synchronicity of the media are helping users to develop new skills more simply comparing to other technologies which could have a positive impact on individual performance. The choice of the task to be performed in these workplaces is very salient to succeed the collaboration.

The Proteus effect (is that people infer their expected behaviors and attitudes of the observation of the appearance of their avatars) is a phenomenon which confirms the importance of the appearance of the avatar and then the effect of customization on the interactions between avatars. The study conducted by Yee el colleagues on the Proteus effect is very interesting because it highlights the change in behavior of the avatar in the 3D environment. Their findings could be another starting point to discuss

customization. In addition, the notion of simulation and simulacra depend on the task performed by the user. In this thesis I am not focused on the task. These two notions are interesting to be studied in future work.

There is a growing trend within organizations to use advanced information technologies to substitute physical means of face-to-face interactions. Consequently, and according to the theories of acceptance and adoption of technologies (TAM and UTAUT), users would be able to integrate new media in their workspace if they find them useful and easy to use. This adoption may be facilitated by the evolution we remark in workspace technologies, as serious games and virtual worlds are becoming very friendly and accepted in workspace. The new generations raised up with video game technologies are now able to make their working tools more customized to their needs and according to their options. According to our experiments, the experience with technology is found with great influence on team interactions. Virtual worlds contain many options and menus as well as many means of communication (verbal and non-verbal) and many types of movements. Users are also able to develop their own add-ons and integrate them safely inside the environment. Mastering the environments is considered as a key element to succeed in virtual worlds. In fact, users should train themselves to better use these technologies and understand their specificities. That's why in this research we tried to meet a business need of designing a collaborative game aiming at training users to better use these environments. And finally, we propose a list of best practices in the next part.

4. How could we enhance collaboration in 3D virtual worlds ?

4.1 Serious game

In the aim to enhance collaboration, and based on findings from our studies, we find that the enhancement of collaboration could be achieved by fostering determinants that enable collaboration and trying to reduce the impact of those that inhibit it.

We designed a serious game that could expect social loafing through the behavior of players and punish them with penalties. In addition, through this game, we can learn the threshold of interactions between players that provoke the drop of team performance. Besides, we learnt that succeeding collaboration in 3D virtual

environments is based on the experience with the technology. Mainly object manipulation and customization to be mastered by users. In the same time, basing on findings about knowledge sharing and knowledge application we found that users could succeed collaboration in these environments when they know exactly most appropriate tasks to be executed on these environments. So they can share specific type of knowledge and apply it in the most convenient context.

4.2 Best practices

After the study of collaboration in 3D virtual worlds, we provide a list of best practices from our studies and results and also from the literature. We can classify these best practices into individual, collective, use and adoption and design:

Individual

- Considering the understanding of the technology assets, this. will help to understand its strengths and be able to take advantage from them.
- Considering the importance of being at ease with the avatar and the environment. Users could customize their avatars and environment in the best way that makes them like their appearance en workspace.
- Considering that the chosen appearance of avatars is respecting other teammates.
- Considering that virtual worlds are not as rich media as a face-to-face setting and trying to be sure that teammates understand you point of view. This helps teammates to avoid misunderstandings and conflicts.
- Considering warm and synchronous interaction with other teammates in the aim to maintain a good level of co-presence.
- Considering the review of organizational ethics policy in the aim to avoid any transgression to the law.
- Considering the spread of awareness about the consequences of social loafing on the individual and the collective level.
- Do not mix leisure and work; create a business account to avoid wasting time in discussing with friends.
- Asking help from more experienced persons with the technology. This will help to overcome many blocking situations.

- Considering the understanding the importance of knowledge sharing and the application of the shared knowledge in the appropriate context.

Collective

- Considering mapping the lines of good communication between teammates. This will help preparing better workplace for knowledge sharing and collaboration.
- Considering the importance of information reporting and awareness spreading within the team.
- Considering a manageable number of participants in the workspace in the aim to avoid density effects on teamwork.

Use and adoption

- Considering having training on how to better use the technology such as a serious game (BestCollab). This will help teammates to master the technology assets and know how to use is it in a proper manner (avoiding misuse or disturbing other teammates).
- Considering the promotion of individual training to be update with the technology.
- Considering the ability to use the appropriate means of communication to different types of knowledge (for example, user can use gesture when he/she is presenting his/her slides in addition to the voice communication and the panels).
- Considering the ability to create mind maps and charts as results of a brainstorming meeting.
- Considering the ability to demonstrate and later 3D models inside the virtual environment.
- Considering the importance of object manipulation in some simulation tasks and demonstrations. Being aware of appropriate tasks performed on VWs.

Design

- Considering the targeted audience to the virtual world you are developing. This will help to fix most important assets to be developed. This will be appreciated to produce a customized product fitting the requirements of a particular community.
- Creating short movies to advertise about a new event or information.
- Creating tools for decision-making and information reporting.

3. Conclusion

To sum up, we have achieved the mentioned objectives in the beginning of this manuscript. On the one hand, we identified salient determinants characterizing collaboration in 3D virtual environments. Later we categorized them into three categories namely technology, individual and collective. In addition, we studied the impact of using these environments on team performance by establishing research models and conducting quantitative studies.

On the other hand, our objectives met the business need. In fact, we have provided a deep understanding on how to collaborate in a better manner in these virtual environments taking into account determinants identified in the literature and through exploratory study. We provided a list of best practices to use 3D virtual environments in workspaces. These best practices should be approved by a focus group of professional working on virtual worlds. We have designed collaborative scenarios (Serious Game) allowing users to understand collaboration in 3D virtual environments.

CONCLUSION

Over the past five years, VWs have evolved from being fancy chat rooms to virtual communities that support personal spaces, marketplaces, collaboration, and V-learning. VWs are pervading our daily life and are working their way into our office. They seem to be an object of diverse opinions, criticisms and support, ranging from the fear of losing team performance to the considerable advantages of distributed team collaboration. As VWs are relatively cheap and easy for anyone to access remotely from everywhere at anytime, they can save time and travel efforts. Consequently, the adoption of VWs into our daily lives and organizations is expected to increase in the future in the age of Web x.0. However many threats or issues remain unresolved. These obstacles could have some negative effects on the adoption and acceptation of virtual worlds by teams due to leadership issues, data security problems and even psychological challenges to individual users. This research aims to provide research models that help to understand the added value of these new media and the way they impact team performance. This will give a concrete response to manager wishing to use this kind of technology. It focuses particularly on the study of the determinants of this particular kind of collaboration and its impact on team performance.

A qualitative lab study has conducted in order to bring a first experiment on collaboration in VWs. This study helped us to identify a set of relevant determinants from an expert point of view which will be supported by references from the literature. So the lab study will contribute in the design of research models linking determinants of collaboration in 3D virtual worlds to team performance.

Two quantitative studies have been conducted. The first one aims at comparing the impact of Skype and Second Life on virtual co-presence, cognitive absorption and ultimately team performance. The second one is specific to virtual environments; it allows assessing the impact of VW use and social loafing on knowledge sharing and knowledge application in the 3D virtual setting

From the design science side, we designed collaborative scenarios focusing on relevant collaboration determinants such as knowledge sharing or social loafing. These scenarios are integrated in a collaborative serious game. This latter is bringing a kind of training to virtual worlds' users and taking into account 3D VWs' specificities. We provide two versions, targeting project manager and team member.

Next, we elaborate on the key contributions of our study to the IS literature. We can classify the contributions of this research into three main types:

1. Theoretical contribution

The study of literature focused on virtual worlds and serious games. We studied a sample of fifteen relevant virtual worlds in the aim to shed the light on most important activities performed on these environments. We focused also on communication tools (verbal and non-verbal) which give a distinguishing asset to virtual worlds. In addition, we studied the technological feature of avatar and environment customization and object manipulation inside them. The study of the communities and the main activities of each of these virtual worlds highlighted the importance of the different features of each virtual world mainly object manipulation and customization. The importance of these two features will be supported later in the second quantitative study.

Videos games and serious games have been also studied in the context of this thesis. They constitute an ancestor of virtual worlds. In the same time, nowadays, games are not only used for entertainment but also they are used as powerful tool for learning. Game designers are integrating serious content in the game play in the aim to make the experience of play more benefic leading to the achievement of a set of pedagogic goals.

We studied the literature about determinants of 3D virtual worlds and selected a list to be studied. We used a selection grid of relevant criteria in the aim to focus on determinants that :

1) Have not been studied before in the context of 3D virtual worlds
2) Are characteristic of the medium such as object manipulation or customization
3) Are identified in the literature of virtual teams to be very crucial to collaboration such as knowledge sharing
4) Are with influential impact on virtual worlds such as cognitive absorption

This Literature review served to understand what people are able to do in these environments, their feedbacks on performance and their acceptance of such new media. We characterized this specific collaboration in virtual world comparing to other technologies.

The SWOT analysis conducted in our exploratory study brought additional insights about the use of virtual worlds in workspace. This study brought main strengths, weaknesses, opportunities and threats of the use of virtual worlds in workplace. It supports that VWs could be a good alternative of the face-to-face setting. In fact they are relatively cheap and easy for anyone to access remotely from everywhere at

anytime. In addition, they can reduce distances and costs and save time and travel efforts. They allow real time and rapid communications and allow an easy knowledge sharing which is one of the bases of virtual team collaboration. In addition, VWs are customizable environments and have a gaming aspect which allows people to feel more comfortable when working in a pleasant and flexible environment that they can control. Avatar customization is important because it allows users to express their personality and utilize an avatar to they can relate to, which makes them more engaged during VW activities when their avatar reflected users' persona. Moreover, the ability to create and manipulate objects in VWs offers the possibility to increase the creativity of users, and help users to develop their interpersonal skills.

However many threats or issues remain unresolved and could have some negative effects on the adoption and acceptance of VWs by teams in workplace. In fact, VWs' lack a juridical framework and provide poor security against hacking, fraud and identity theft. In addition, several problems could occur mainly due to the lack of face-to-face and body language communication. In addition, VWs require advanced technical skills. This qualitative study helped us to identify a set of determinants basing on the experts point of view such as knowledge sharing, object manipulation, etc.

- **Two research models**

We have developed two research models. The first one highlighted the study of the impact of both Skype and Second life on team performance. This study brings relevant insights about the difference between the dynamics of these two technologies. It shed the light on the importance of virtual world as a powerful technology to support teamwork. It focuses on the effect of co-presence and cognitive absorption which have been to be more important in Second Life comparing to Skype. In addition, this research highlighted the negative effect of density in both technology and supports that this determinant has been found to be more significant in Skype comparing to Second Life.

This research supports the importance of the choice of the technology to support collaborative activities which is coherent with the virtual teams' literature. Indeed, cognitive absorption and co presence have more significant effect on team performance

in 3D virtual world setting. This could be explained by the richness of the medium and its capacity to support collaboration.

A second research model is designed to take into account new determinants. This study is centered on virtual worlds and targeted three different levels namely (technological, individual and collective). This study highlights the moderating effect of two assets of this technology on the impact of technology usage (group support system use) on knowledge sharing. It focuses on the collaborative dynamic inside the team by studying the negative impact of social loafing on knowledge sharing. This study brings more insurance about the ability of virtual worlds to support group work and the impact of their use on team performance. This study highlighted that knowledge sharing is a crucial determinant which fosters team collaboration. It is found to be influenced by the human behavior (social loafing) and the capacity of the technology (influence of customization and object manipulation).

Knowledge application has a positive effect on individual performance. It is considered as important and complementing the role of knowledge sharing.

These two studies bring responses to managers about the assets of virtual worlds and their impact on team performance. Successful collaboration could be feasible using these environments. In the aim to enhance team performance, man should focus on determinants which foster team collaboration and try to lower the effects of inhibitors. This could be done by the knowing best practices of team collaboration in 3D virtual worlds or using a game to train team members how to collaborate using these technologies.

2. Practical contribution

- **Design of a serious game supporting team collaboration in the project management field:**

We designed a new serious game aiming to foster teamwork and taking into account the set of identified determinants of the conducted experiments. This game presents a set of collaborative scenarios with a variety of challenges and focusing on predefined learning goals. Two types of scenarios are provided namely for a project manager and for a teammate. This game is bringing a learning-by-doing experience to its users and

makes them apprehend new skills mainly about team collaboration. This game is supposed to simulate a working place within a team in a virtual environment context.

As we have mentioned in the previous chapter, the experience with the technology is very crucial to succeed team collaboration in 3D virtual environments. So the usage of a serious game having a similar graphic with 3D virtual worlds, could be useful to make better use of the technology and benefit of all its assets.

This game could be enriched with more scenarios related to different determinants of team collaboration. It could be used to bring more experiments on team collaboration in virtual worlds by providing a guided-collaboration platform for game users.

This game could be considered as a first step towards a collaborative serious game aiming at providing Learning-by-doing experience to people willing to use 3D VWs in their workplace.

The development of the game is not intended to target a particular type of virtual team. The context of collaboration, team size and different characteristics of virtual team have an impact on the relevance of the game. The game is developed to allow users to learn to work in virtual worlds. At the same time it allows the change in collaborative situations (variation of control variables such as the size of the team, etc.) in order to test the impact of these characteristics on the collaboration of a longitudinal and incremental manner as the generalization of results can be made only after a large number of experiments and according to specific conditions. The game can be used by students (professional later) to conduct collaborative situations over a period of 20-30 minutes. We can start by testing with students and afterwards with professionals. Skills can be assessed by various scores of the participants. They will be asked to answer a questionnaire that will be a second way to assess the skills and experience feedback. These feedbacks will be used for future improvements of the game. Integration of the game comes out the proposal to use 3D virtual worlds in the work environment .

A successful collaboration could be feasible in these kind of environments thanks to their Advanced design however mastering the technology is a key success factor of team collaboration.

Furthermore, users should be aware of a set of best practices which help them to enhance their use of the technology.

- **Proposal a list of best practices**

We proposed a list of best practices for professional willing to use these media in their workplace. Theses advices are very useful for new users to avoid pitfalls and

understand the particularity of these environments. Best practices are relevant for both project manager and teammates. These best practices are developed based on insights from this research and also from the literature.

3. Methodological contribution

In this thesis, we have integrated the usage of a new serious game in the design and evaluation of theoretical models. The serious game will propose a customizable plateforme to vary collaborative scenarios according to the set of control variables we want to study. It permits to collect data in several contexts which will be interesting and relsoves the issues of finding participants with very precise conditions to conduct a field study.

4. Limitations

This study is not without limitations. First, the use of student subjects in two studies may limit the generazability of this research. Indeed, students are typically different from business professionals and may have less experience with the problem domain. The students are from the digital generation and they are adept with new technologies. They are graduate management students who are very sensitive to virtual project management. The majority of them come from the same geographical location. This could lead to a regional bias. In the aim to deal with this limitation, we can conduct another experiment with professional or we can recontact the students who participated in the study after entering to the work field.

Further, the second quantitative study presents also a set of limitations. The sample gathered was mainly on fourteen virtual worlds. The majority of respondents are working on Second Life. This could be understandable as not all virtual worlds are targeting professionals. Besides, the popularity of Second life makes it the most visited in this kind of virtual worlds.

The results of this thesis are not generalizable that's why the serious game is useful. The generalization of this study requires several studies on several virtual teams according to their characteristics. This requires conducting a lot of experimentation with specific conditions. However, this is not feasible because we are constrained by the field and data collection. Hence, we can understand the importance of the variation of scenarios that I have proposed and the advantage of the combination of behavioral

science and design science. By proposing collaborative scenarios, we can create the situation and the conditions of the experiment (to vary the context e.g. team size without the need to conduct more studies with teams with different sizes). Design science will be in the service of behavioral science when we vary scenarios and at the same time behavior science is in the service of science design because the design was based on the results of qualitative and quantitative studies .

The characteristics of virtual teams have an important impact on collaboration (some features are mentioned on page 72 of the manuscript such as the size and expertise of the team). However, these characteristics are control variables that cannot be studied together but after several experiments.

The idea of our research is to begin by studying the collaboration from three levels of analysis in order to have a starting point by designing collaborative scenarios and later we can create new conditions and vary different control variables.

This work is studying team collaboration from a technological perspective; however, the managerial perspective is not studied in this research.

There are some limitations related to the design of serious game. The game could not provide a high level of customization and object manipulation as in 3D virtual world. This limitation is due to the software we used to develop the game.

In order to complete the Design Science Evaluation Framework, lab experiments and field studies have to be conducted in the aim to evaluate the game artifacts and to further enhance them. Later and after the first lab experiment, the game should be presented to and tested with professionals in the project management field.

5. Perspectives

In this thesis, we are trying to bring pieces of knowledge to understand collaboration in 3D virtual worlds. These latters are a new alternative for companies compared to face-to-face but not replacing it. We are still in the beginning; we hope to put our little stone in this stream of research.

In our next steps, we are planning to present a new research model resulting from the two studied in this research. New scenarios could be designed aiming at taking into account the merging of the two research models.

Further, the game should be tested in with professionals. A qualitative study could be conducted after this first test in the aim to get more feedbacks. A third quantitative study could be conducted with the scenarios presented by the game. This may bring more

relevant results as we can vary variables (gender, professional experience, age, etc.) of the research models and study each of them in a separate scenario.

The game could be used later as training for teams willing to use VWs in workplace. In addition, research could mobilize task technology fit to study the relationship between individual performance and appropriate tasks performed in VWs.

Further, the literature of virtual teams argues that the managerial perspective is crucial and positions the role of the leader and the coordination of the tasks between team members.

Finally, our findings may help organizations to better prepare their venture into VWs by heightening their awareness of the major challenges of this emergent technology. The relevant issues identified in this study also provide a starting point for better understanding and further researching factors that influence the optimal utilization of VWs to conduct team collaboration. Furthermore, the results could encourage managers to adopt these media and take profit of their assets. They can find in our game a serious step towards training people to use virtual worlds; it could open doors to deeper understanding of these technologies and their assets. This games could be considered as an intellectual contribution. The lists of best practices could shed lights on pitfalls to avoid and to succeed team collaboration on VWs. Finally, a researcher could design a solution or a game to address a business need if he/she followed rigorous manners to conduct his/her research. A researcher could design a serious game that could be considered as an intellectual contribution.

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APPENDICES

Appendix 1: 3D Virtual worlds

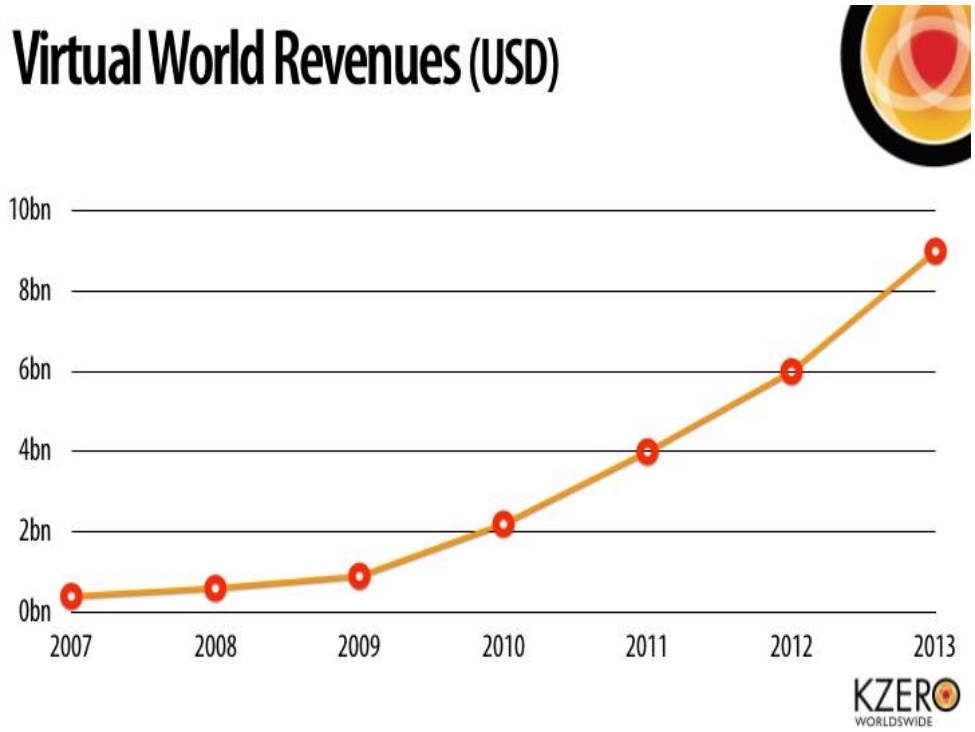


Figure 19 Growth of VWs revenues USD (Kzero)

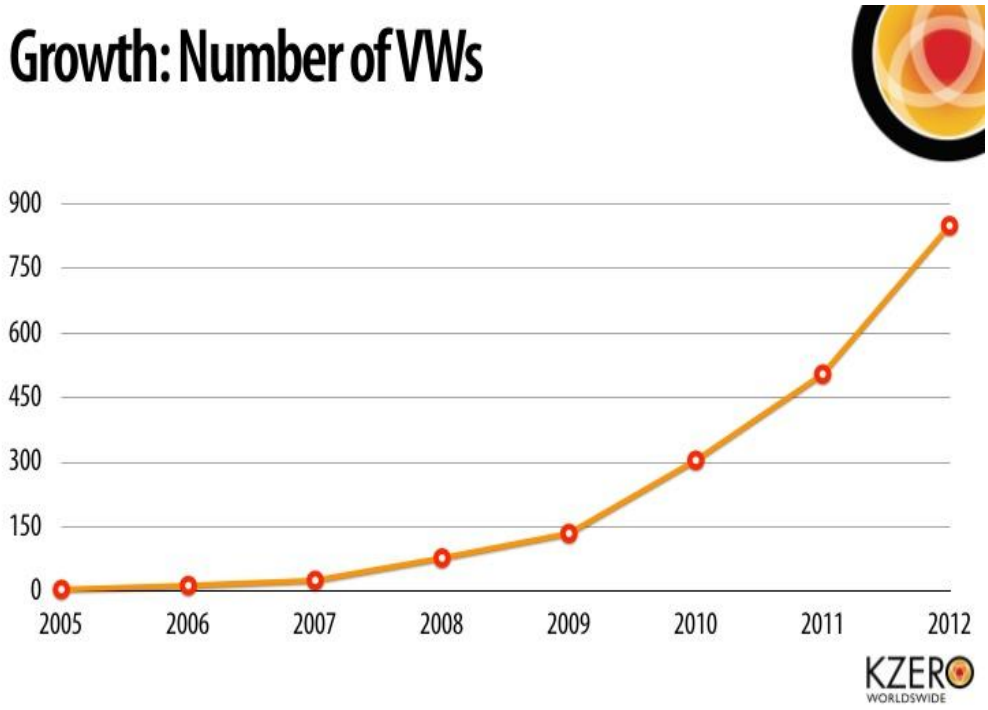


Figure 20 Growth of VWs number through years (Kzero)

Appendix 2: 3D virtual worlds: users, avatars, environments and targeted activities

Name	Number of users	Target	Type
Second life	More than 20 million	>18 year old	Content Creation / UGC
Activeworlds	Less than 1 million	(20-30)	Content Creation / UGC
HiPiHi	1-5million	(20-30)	Content Creation / UGC
Twinity	Less than 1 million	(20-30)	Mirror
vSide	1-5million	(10-20)	Socializing / Open
Habbo	More than 20 million	(10-20)	Socializing / Open
sMeet	5-20million	(10-20)	Socializing / Open
WeeWorld	More than 20 million	(10-20)	Socializing / Open
Kaneva	1-5million	(10-20)	Socializing / Open
LoL[40]	1-5million	(20-30)	Questing / Adventure
WoW	More than 20 million	(20-30)	Questing / Adventure
Neopets	More than 20 million	<10	Casual Gaming
Barbie Girls	Less than 1 million	(10-20)	Toys / Real World Games
There	1-5million	>18 year old	Socializing / Open
IMVU	More than 20 million	(20-30)	Content Creation / UGC

Table 28 Virtual worlds' users

Name	Environment customization	Place of the community in the world	Ease of access to objects	Means of communication (verbal)
Second life	Vey high	Well known	Very high	Voice communication/ text chat/ private messages
Activeworlds	Medium	Moderately known	Low	Voice communication/ text chat/ private messages
HiPiHi	Medium	Well known	Medium	Text chat/ private messages
Twinity	High	Known	High	Voice communication/ text chat/
vSide	Medium	Less known	Medium	Voice communication/ text chat
Habbo	High	Known	High	Voice communication/ text chat
sMeet	Low	Known	High	Voice communication/ text chat/ private messages
WeeWorld	Low	Known	Very high	Text chat/ private messages
Kaneva	Low	Well known	High	Voice communication/ text chat/ private messages
LOL	Low	Well known	High	Voice communication/ text chat/ private messages
WOW	High	Well known	Very high	Text chat/ private messages

[40] LoL is the abbreviation of League of Legends

Neopets	Medium	Moderately known	Low	Text chat/ private messages
Barbie Girls	Medium	Less known	Medium	Text chat
There	Medium	Known	Medium	Voice communication/ text chat/ private message
IMVU	High	Well known	Medium	Voice communication/ text chat/ private message

Table 29 Environments in virtual worlds

Name	**Ease to manipulate the avatar**	**Ease of object manipulation**	**The degree of possible customization of the avatar**	**Surfing types**
Second life	Very high	Very high	Very high	Walking/ teleporting/ flying
Active worlds	High	Low	Low	Walking/ flying
HiPiHi	High	Medium	Medium	Walking/ teleporting/
Twinity	High	High	High	Walking/ teleporting/
vSide	Medium	Medium	Medium	Walking/ teleporting/
Habbo	High	High	High	Walking/ flying
sMeet	Medium	High	High	Walking/ teleporting/
WeeWorld	Medium	Very high	Very high	Walking
Kaneva	High	High	High	Walking/flying
LOL	High	High	Medium	Walking/ teleporting/ flying
WOW	High	Very high	High	Walking/ teleporting/ flying
Neopets	High	Low	High	Walking
Barbie Girls	Low	Medium	Very high	Walking
There	Medium	Medium	High	Walking/flying
IMVU	Medium	Medium	High	Walking/ teleporting/

Table 30 Avatars in virtual worlds

Name	Targeted field
Second life	Advertisement/v-learning/v-collaboration/ social networking/ professional networking/ dating
Activeworlds	Dating/ social networking, entertainment
HiPiHi	Dating/ business/ social networking/
Twinity	Dating/ business/ tourism/ social networking
vSide	Dating/ business/ social networking
Habbo	Dating/ social networking/ entertainment
sMeet	Dating/ social networking/ entertainment
WeeWorld	Gaming
Kaneva	Gaming
LOL	Gaming
WOW	Gaming
Neopets	Gaming
Barbie Girls	Gaming/ social networking/ entertainment
There	Dating/ social networking/ entertainment
IMVU	Dating/ social networking/ entertainment

Table 31 Targeted fields by different virtual worlds

Appendix 3: Second life

Second Life is a persistent universe 3D virtual world. The player is prompted to live and create a new life where one can explore the world, create new objects, connect with other users, build houses and present projects, attend courses and collaborate remotely. Users can attend conferences, chat, date, etc.

Compared another types of VWs, Second life provide a more open-ended experience for the user, as users can create more of their own experience because these environments are mostly constructed by the users themselves.

Another aspect of this virtual environment is the ability to trade and buy goods using a virtual currency, the Linden Dollar (L$). The objects thus created are legally protected by Creative Commons licenses and freely tradable.

Second life was selected by many international corporations[41] to host their "virtual headquarters" such as IBM, Intel, Coca Cola, etc. Furthermore, a European project – the AVALON project[42]- for virtual learning has chosen Second life to host many of its activities.

Second life provided several account types. The first account "Basic" is free and provides access to events, shopping, etc. After the first free account, all others cost 9.95 USD. The Premium account is at 9.95 USD per month and allows for 512m2 of land on which to build. If the player wants more land, he/she must pay more per month. For example, for 195 USD / month, the player can have a plot of 65,000 m2. Today there are more than 36 million subscribers to Second Life aged more than 18 while Teen Second Life is available at the same rate as Second Life and targets teens aged between 13 and 17 years.

Second life community is known to be very strong and highly connected. Actually, several mailing lists are set to support users and developers. Blogs, forums, wiki pages and knowledge base resources are also available to them. According to Second life official site, in its 10th birthday, it recorded 217,266 years time spent by all users since 2003.

[41] An exhaustive list is given in this site http://www.nbhorizons.com/list.htm
[42] http://avalon.humanities.manchester.ac.uk/

Appendix 4: World of Warcraft

World of Warcraft, more commonly known by the acronym "WoW", is a Massive Multiplayer Online Role Playing Game (MMORPG). MMORPG is a kind of role playing video game where players interact with each other within a virtual environment (Bartle 2003; Kelly 2004). It is a popular type of Massively Multiplayer Online Game (MMOG). The “massively multiplayer” designation is inspired from the capability of MMORPG to host thousands of users worldwide online together. Scalability of MMORPG allows unprecedented occasion for social interaction between dispersed users. According to Cole and Griffiths (2007), MMORPGs are highly socially interactive environments which provide “*the opportunity to create strong friendships and emotional relationships*” (Cole and Griffiths 2007) p.575.

WoW is probably the benchmark for online gaming which was released in 2004 and produced by the company Blizzard Entertainment. It is a persistent virtual world where players from around the world compete and collaborate to epic challenges.

Since its creation 9 years ago, WoW is increasingly growing due to its evolving nature, as there is a regular add of new content. In addition, regular updates ensure optimal functioning. Three main extensions came to improve the game (in 2007, 2008 and 2010). Each extension offers new challenges more difficult than the previous. WoW continues to attract and retain fans despite the emergence of competitors with more modern graphics, such as Aion. Moreover, WoW gives the opportunity to the player to shape the universe that contributes to its evolution. Players can develop "add-ons" or modules (programs) to customize and optimize the game interface. Players could feed the WoW Wiki, the second largest wiki in the world after Wikipedia, which contains no less than 95,000 different pages in its English version, powered exclusively by WoW players.

Guild is a key dynamic component of WOW where players are working in groups and collaborate in the aim to unlock new loots and defeat monsters. World of Warcraft universe is a particularly interesting regarding the interactions between people. It is indeed a real online company, with its own codes of conduct.

WoW is a complex game, offering many challenges. Players must form teams (teams of "raid") and successfully coordinate to defeat enemies in extremely difficult dungeons. The principle of a MMORPG is to encourage collaboration because the challenge given in the game is almost impossible to be done by one person.

In addition, the game evolves with the actions of the players, which makes it even more complex. Indeed, a person will not have the same state of mind, or the same equipment, the same companions during the game. It encourages the establishment of collaborative microcosms: guilds. Indeed, WoW players organize themselves into guilds, which are associations of players tending towards the same goal: successfully finish the elite of the game content (raids). Within guilds, raid groups of 10 to 25 players are organized. These players must work as a team together to develop their skills and content knowledge to advance. Each group develops a kind of tacit knowledge content, so it is not always easy to share with others. They develop wikis, blogs and forums specific to the guild or raid teams' discussions and share their experience. They even discuss strategies to find the best way to finish over dungeons.

Collaboration between guilds is the knowledge economy in WoW; Apart from internal discussions guilds, knowledge sharing is spread between guilds aiming at establishing knowledge base for players.

- Tens of millions of posts on the official forums;
- Tens of thousands of private forums;
- The creation of "Wow wiki", the second largest wiki internet after Wikipedia;
- Strategy videos shared on YouTube[43];
- Blogs dealing with optimization strategies and performance;
- Etc.

All of these resources contribute to the existence of a system of knowledge sharing, facilitated by the community itself, extremely powerful. In fact, players communicate first and foremost with other players: interactions with the company Blizzard are very limited in number compared to the interactions between players.

[43] www.youtube.com

Despite this impressive knowledge sharing, WoW is a game where competition is a fundamental component. It is located on two levels: inter-guild competition and the international players.

Player develops new skills and qualities through his/her experience in World of Warcraft. It is therefore possible that he / she considers him / herself more legitimate in the exercise of certain managerial responsibilities. This process may be aware (the player knows when more experienced in areas directly applicable to professional practice) or unconscious (confidence player reflects on the overall confidence of the individual, without noticing necessarily).

Appendix 5: Different types of serious games

In recent years, there has been an increasing interest in how digital games can be used to support serious objectives such as learning, training, collaborating and teaching in formal education environments. Several researches argued that digital games, including simulations and virtual worlds, have the potential to be an important teaching tool because they are interactive, engaging and immersive activities (Shaffer, 2005; Smith, 2007; Gee, 2008). Companies are attracted by this kind of game because they are practical and very well accepted among employees especially those of the young generation. Further, they have a set of potential benefits such as improved self-monitoring, problem recognition and problem solving, decision-making, better short-term and long-term memory, and increased social skills such as collaboration, negotiation, and shared decision-making (Rieber, 1996; Mitchell, 2004; Ellis, 2006). Usage of serious games is very wide and touches multiple sectors such as:

- Defense Sector/Military (e.g. America's army, Full Spectrum Warrior, Close Combat: Marines): It is one of the most important sectors in terms of investments made by contractors. This kind of games is used by armies, but its use is less widespread.
- Health (e.g. Pulse, SharpBrains, the power of research, HumanSim, Nano missionTM): Nintendo has been very successful with the applications to brain training and fitness.
- Vocational and recruitment simulation (Ace Manager-The Second Set, Star Bank The Game), project management (Prendo).
- Advertisement (The coke zero game): Serious games dedicated to advertising (advergames) offer the feature of exposing users to a brand or a product over the life of a party.
- Formal education settings/ Education and Training Sector (happyneuron.fr, LearningBeans, History of Biology game, The Brain Training from Dr. Kawashima: How Old Is Your Brain?): The serious gaming invests naturally in this market. For instance, 40% of e-learning applications use the serious gaming in later 2008 in the USA.

- Sector Information and communication: The communicative dimension related to advertising (edumarket game) enters the market of in-game advertising, which weighs 205 million USD in 2008 in the United States.
- Culture Sector: It represents a negligible proportion of serious gaming for now, but can greatly expand, through cultural tourism and industry in particular.
- Area activist: It has the peculiarity to escape economic models: the creations are often made without financial resources for the sole purpose of expressing a committed message, like The 12th September dedicated to the attacks of September 11.

Taking into account their main intentions, serious games can be divided into three broad categories:

- Serious games with a message: they share the intention of conveying message in an educational, informative, persuasive issue, etc.
- Serious games for training: they share the intention to improve cognitive performance or motor users.
- Serious games simulation or serious play: they share the characteristic not to present an objective to assess users. By this approach, these applications offer a range of open uses.

Alvarez (2007) gave another classification: Advergames (games for advertisement), Edugames (educational games), Exergames (games providing exercises), Datagames (games based on data banks), Military games, Green games (games focusing on ecology), Newsgames (informative games) and Edumarket games (games combining educational or informational messages with marketing).

Appendix 6: Characterization and evaluation of serious games

Three main grids for evaluating SG have been developed. The first one is G/P/S proposed by Djaouti and Jessel (2011). This grid allows evaluating (approximately) the gameplay of SG with gain comparing to SG without gain. In addition, it allows characterizing the serious objective of the SG (passing a serious message, training, advertisement etc) and to define the sector targeted by the game (military, health, public etc). Thus, this grid provides a classification scheme that could not be considered as an assessment tool. In addition, only three aspects have been taken into account namely gameplay, objective and targeted sector. Indeed, this grid didn't provide any qualitative information, thus we cannot judge if a SG is effective, clear or easy to use. Finally, the number of evaluated criteria related to these aspects is restrictive (only six criteria).

Second, Peterson and colleagues (2008) proposed a grid allowing the evaluation of several aspects of SG for young children such as curiosity exploitation, mastery of the game, challenge, social, pedagogy, technology etc. This grid refers to SG targeting children sector only. In addition, the value scale used by this grid is binary. Indeed, every aspect of a SG is divided into several criteria that the game could fulfill or not. Besides, this grid does not provide qualitative aspects which are necessary to achieve a complete evaluation of SG.

This grid is dedicated to educational SG only; it does not focus on other fields. This grid does not determine give any description of technological aspects (e.g. accessories, architecture, programming...). No information is provided on the game execution. Besides, the grid does not focus on users' appreciation which can be useful for new users of the game. Finally, this grid has a high number of evaluation criteria (44).

Third a grid developed by Boughzala et al (2013), it is a reusable and precise covering all useful aspects for a complete evaluation. This grid takes into account different criteria omitted by the previous grids and especially to allow qualitative evaluation using a graduated measurement scale.

Name	G/P/S Grid	Peterson Grid	G-CE-SG
Reference	(Djaouti and Jessel 2011)	Peterson (2008)	Boughzala et al (2013)
Grid objective	Classification	Evaluation	Characterization and Evaluation
Value scale	Graduated and binary	Binary	Graduated
Evaluated aspects	Objective	Objective	Objective and subjective (qualitative)
Audience targeted by the SG	• Public • Professionals • Students	• Children • Children with special needs	• Public • Professionals (public and private corporation) • Professional in higher education • Students (initial and executive education)

Table 32 Comparison between evaluation grids (Boughzala et al. 2013)

Appendix 7: Virtual project management in VWs

Several media are used to communicate information and knowledge and to make decisions. The question is about the media ability to allow knowledge sharing, work achievement and team distant management. Indeed, media with higher level of synchronicity lead to greater job satisfaction (Hassell and Limayem 2010). Hassel and Limayem (2010) suggested also that presence and social presence play an important role in the relationship between job satisfaction and the level of media synchronicity. In addition, Damart and colleagues (2010) argued that immersion is a common property between meetings and virtual worlds (Damart et al. 2010). Furthermore, Wang and Haggerty (2009) declared that several factors such as economic forces, competitive pressures and technological advances have led to creating new environment for organization such as VWs and management like Knowledge management in the aim to maintain and enhance their performance. Moreover, individual virtual competency should be well understood because it's a potential avenue to manage knowledge sharing and transfer in VWs. So, according to Wang and Haggerty (2009) optimal knowledge transfer could be achieved by user having the right personal skills and capabilities for VWs. They considered that the prior experience in virtual activity has a significant role for effective knowledge transfer.

Appendix 8: Facilitation

Two types of facilitation exist in the literature namely: process facilitation and content facilitation. In the first type, the facilitator contributes indirectly in the team's final solution and manages communication process and information processing (Anson et al. 1995; Bessière et al. 2009; Griffith et al. 1998). In the content facilitation, the facilitator contributes with knowledge and helps to resolve conflicts and provides a structure to the collaboration process (Eden 1990). As any of collaboration practice's components, this element could be impacted by new collaboration technologies.

Appendix 9: Immersive v-education/v-learning

We can identify four types of learning in 3D virtual worlds:

- Teaching in virtual classroom: Teachers give courses in a virtual auditorium where access has been limited by the organizer (the course can be provided free of charge or open access) to a number of students who "moved" their avatar to this auditorium. Many opportunities are proposed by universities for distance learning. Indeed, it is now possible to follow lectures in over 200 universities and colleges in virtual worlds such as Second life.
- Learning through group work: Virtual worlds can be a valuable tool for collaborative work remotely. It is a kind of simulation of group work where people can learn how to work with other.
- Learning through role-play, simulation exercises where the user can learn to respond or to react according to a certain situation. The "role-playing" is an effective tool to experience training without leaving home. Virtual worlds provide total flexibility and interactivity capabilities making these tools a great success. These simulations can make the experience very similar to a real course with its immersive nature, improvised and realistic décor.
- Learning languages: Language learning occurs either directly conversing with native speakers or by attending classes. These courses are offered by private organizations such as Languagelab or AvatarEnglish. Some institutions such as the Goethe Institute's offer free German courses. Anywhere and at any time, it is possible to delve into a fully interactive world combining all the necessary tools for language learning namely sound, voice and image. For instance, some islands grow on Second Life such as "Second Life English" welcoming more than 5,000 students willing to learn English. The student is confronted to different practical situations (order lunch in a restaurant, ask for directions) which allowing the apprehension of everyday vocabulary.

Nowadays 3D virtual worlds are becoming increasingly popular as a means of pedagogical delivery in higher education (Chen et al. 2010a; Chen et al. 2009; Phang and Kankanhalli 2009), they offer a great potential to improve and enhance education (Eschenbrenner et al. 2008; Zigurs and Zhang 2010). They are more adequate to the group-oriented learning than the e-learning technologies (Franceschi et al. 2009). In

fact, 3D VWs provide a common or shared visual space where students meet and interact using their avatars (Franceschi et al. 2009) they allow a sense of being there in class (virtually being there) (Ferratt and Hall 2009) and created new possibilities for formal and informal processes of education and knowledge sharing (Bredl 2009). So students are sharing a kind of quasi-realism of the 3D environments and also manipulate artifacts together which strengthen the sense of group presence and lead to engaging group learning interactions (Franceschi et al. 2009). In addition, These new environments could simulate students' self-efficacy and their outcome expectations (Rosario et al. 2008) and could help researchers to overcome the geographical issue facing innovation activity (Wasko et al. 2007). Besides, in interactive instructional sessions, students felt higher level of classroom interactivity in the 3D virtual world (Second Life) than in the traditional classroom (face-to-face) (Chen et al. 2010b). For instance, Robbins and Butler (2010) gave a prototype of the development of a virtual teaching case in the aim to provide a more engaging environment where students can practice project management skills collaboratively (Robbins and Butler 2010).

The main advantage of the use of 3D virtual worlds is the reduction of costs. In fact V-learning is a way to reduce overall learning costs (materials, travel costs, joining big number of people simultaneously) while maintaining the majority of the benefits of formal education comparing to traditional E-learning.

In addition, V-learning reduces distances. The speaker may be located thousands of kilometers far of the learner. While this latter can visualize the teacher in the virtual auditorium. The psychological distance is reduced also as the student is immersed in a virtual world, feeling social presence. The learner feels less loneliness and can more easily overcome the risks of self-study (risk of discouragement and abandonment of learning).

The anonymity, may cause some security issues, but in the context of a course, it facilitates communication by overcoming shyness and encourages self-expression.

Technologies connected directly to these virtual worlds support the distance learning arrangement and they are helpful to transfer and gain knowledge (Stieglitz et al. 2010). In fact, some researchers are investigating the extent to which VWs may

lead to key learning outcomes such as satisfaction and effectiveness (Hassell et al. 2009). Hassel and colleagues (2009) argued that users of VWs may perceive themselves as being in the world where they could interact with others and share pleasurable experiences, so they are more likely to experience positive learning outcomes (satisfaction and effectiveness). Authors discovered that flow decreased the effectiveness of learning and they didn't find any significant difference between traditional face-to-face and virtual learning in both learning satisfaction and effectiveness.

In spite of the great potential offered by virtual worlds to enhance the distance learning, several challenges are facing educators and technology designers to allow efficient distance learning (Ferratt and Hall 2009). Ferratt and Hall (2009) highlighted some important features of their vision that are challenging this kind of learning. Some are related to technology limits on sharing knowledge and information (video, audio and screens) between all participants (Ferratt and Hall 2009). Some challenges are related to the adoption of the technology and the factors that attract students to VWs (Zigurs and Zhang 2010). Several researchers (Chen et al. 2009; Keller 2009) investigated factors influencing the students' and academic staff's intention to adopt 3D VW in learning. Keller (2009) suggested that culture is a salient contextual factor that impacts acceptance of VLE (Virtual Learning Experience) both positively and negatively. Besides High degrees of performance expectancy, results demonstrability and social influence have a positive impact on the acceptance of the virtual learning environments (Keller 2009).

In the same research stream, Zhang and colleagues (2009) declared that research in online education has demonstrated the importance of the sense of classroom community (SCC) in learning. They demonstrated that significant relationship between SCC and learning satisfaction exists. Zhang and Zigurs (2009) studied the social presence and student interaction and considered them like significant factors in virtual learning. Authors suggested that students didn't perceive a high level of presence in VW. They found that no significant relationship is reported between perception of presence and students' interaction (Zhang and Zigurs 2009). Students' perceived social presence has a significant relationship with the perceived interaction of students and learning satisfaction (Zhang 2009).

Appendix 10: Leadership and social skills

Guilds are formal groups allowing players to concretize their strategic collaboration. Social skills are being learnt and practiced when playing games. For instance, players who played helpful games are more likely to describe the game characters in the story. They are more likely to feel empathy about others (Narvaez et al., 2008). Jackson and colleagues (2011) argued that video games are strongly correlated to children creativity. Children have been found more creative in some kind of tasks such as drawing and writing stories. According to Lenhart and colleagues 2008, the pew researchers have found that video games afforded adolescents with rich social interaction and civic learning opportunities where players helped each other, made decisions that affect the group of players and debated moral, ethical and social issues. Games mastery and knowledge is increasingly becoming a considerable part of adolescents' subculture, it forms a part of their social capital and influences the nature of their subgroups (Raney, smith and baker, 2006).

Several pro-social behaviors have been witnessed in games such as positive social skills, generosity and helpfulness, creative and task motivated play and self-regulation (Lenhart et al 2008).

Assmann and colleagues (2010) declared that MMOG are giving new opportunities for researchers to study the virtual teams and organizations. In fact, MMOG have several characteristics that allow obtaining objective data from large and multi-national communities over a long period of time. Consequently, MMOGs allow doing longitudinal studies over virtual communities. Indeed, MMOGs are complex social entities which contain player-founded organizations and mirror our real-world (Goh and Wasko 2009). They investigated attempts to identify potential leaders basing on social network analysis. Goh and Wasko (2010) explained that player-founded organizations, called also guilds, require leaders possessing a set of skills such as management degree, meditating conflicts, planning, controlling, motivating (Goh and Wasko 2010). Like in the real world, these skills are a success key for these organizations. Consequently, academic and business worlds are interested in such leaders. IBM and Google are exploring leadership characteristics and their applicability to management practice (Goh and Wasko 2010). According to

Yee and colleagues (2006), in MMO advancement often necessitates increasing the level of collaboration between players. Hence, players are usually participating in guilds or in a raiding group. In these organized groups, strong teamwork and good leaders are required in the aim to defeat the strongest monsters of the game.

Appendix 11: The survey of the field study

Investigators
Ikram Bououd
Sana Rouis
Imed Boughzala

Description
This research aims to advance our understanding of individuals' usage styles on various social media technologies, their collaboration through these technologies and its impact on their knowledge sharing and "new" knowledge application. The survey has 11 key questions.

The current study focuses only on 3D virtual worlds.

Procedure and Participation
As a participant, you will complete the survey by answering the questions therein. Online based surveys will be administered to participants to capture their perceptions and experiences anonymously. The total time for completing the survey will take about 15 minutes depending on your speed of reading the questions. Your participation in the research is completely voluntary.

Confidentiality
All information will be recorded anonymously and results from the research will be reported as aggregate data; so participants cannot be identified.
If you have any questions or concerns about this study, you may contact Ikram Bououd at Ikram.bououd@telecom-em.eu

1. **On average, how frequently do you use virtual worlds ? Frequency**

Traditional virtual world		3D virtual world	
	Never/almost never		Never/almost never
	A few times a month		A few times a month
	About once a day		About once a day
	A few times a week		A few times a week
	Several times a day		Several times a day
	Less than once a month		Less than once a month

2. **On average, how much time you spend on virtual worlds? Time spent**

Traditional virtual world		3D virtual world	
	Never/almost never		Never/almost never
	A few times a month		A few times a month
	About once a day		About once a day
	A few times a week		A few times a week
	Several times a day		Several times a day
	Less than once a month		Less than once a month

3. **Please indicate to which extent you use each of these activities on both virtual worlds? Nature of use**

1: Not at all **2: To some Extent** **3: Moderately** **4: High** **5: Very High**

Activities		1	2	3	4	5
Traditional virtual world	Entertainment purpose					
	Work purpose					
3D virtual world	Entertainment purpose					
	Work purpose					

Which of these virtual worlds do you use the MOST? (Please select maximum 3 ranking them from 1 to 3 with 1 the most used one)

Second Life

IMVU

There.com

Other: Please Name it:

In the next questions, please use the following scale (we need to precise the exact labeling of the level in each question and not only use 1, 2, 3 etc.):

1: Strongly disagree
2: Disagree
3: Somewhat disagree
4: Neither agree nor disagree
5: Somewhat agree
6: Agree
7: Strongly agree

4. Please rate how much you agree or disagree with the following statements:

	1	2	3	4	5	6	7
I use the virtual world to perform routine and repetitive tasks related to my work							
I use the virtual world to monitor status of day-to-day operations (e.g., cost, sales, projects, customer relations, etc.) for deviations from standards							
I use the virtual world to take immediate corrective actions based on the monitoring of current status							
I use the virtual world to plan my daily or weekly work activities							
I use the virtual world to conduct analysis (e.g., analysis of sales trend, customer defection patterns, what-if scenarios, etc.) for better decision making							
I use the virtual world to pinpoint causes of certain problems related to my decisions							
I use the virtual world to explore more alternatives in decision making							
I use the virtual world I need to acquire crucial information and knowledge related to decisions							
I use the virtual world to communicate with my teammates							
I use the virtual world to engage in joint efforts or projects with teammates							
I use the virtual world to attempt to explore more alternatives in decision making							
I use the virtual world to share information and knowledge with teammates.							

5. Please answer the following regarding your perception of the customization options available on the main virtual world you use:

	1	2	3	4	5	6	7
The virtual world enables users to customize the equipment of their avatar							
The virtual world enables users to customize the accessories of their avatar							

The virtual world enables users to customize the decorations of their avatar							
The virtual world enables users to customize the appearance of their avatars							
The virtual world enables users to create customized goods for their avatars							
The virtual world enables users to create customized equipment for their avatars							

6. **Please answer the following regarding your perception of the objects' manipulation ease on the main virtual world you use**

	1	**2**	**3**	**4**	**5**	**6**	**7**
It is easy to select an object on the main virtual world I use							
I can see reactions (sound or a graphical movement) when selecting an object							
I can touch an object easily							
Once I selected an object, I can move it easily							
Once I selected an object, I can have control on it easily							
Once I selected an object, I can see reactions to each made on the selected object							
I can release an object easily							

7. **Please rate how much you agree or disagree with the following statements Social loafing**

	1	**2**	**3**	**4**	**5**	**6**	**7**
I defer responsibilities I should assume to others							
I put forth less effort on the job when other collaborators are around to do the work.							
I do not do my share of the work.							
I spend less time helping others if other collaborators are present to serve them.							
I put forth less effort than other members of my work-group.							
I avoid performing housekeeping task as much as possible.							
I leave work for the next shift which I should really complete.							
I am less likely to approach anyone if another collaborator is available to do this.							
I take it easy if other collaborators are there to do the work.							

I defer my activities to other collaborators if they are present.							

8. **Please answer the following regarding your opinion about your general attitude toward sharing information and knowledge in your present organization. Knowledge Sharing**

	1	2	3	4	5	6	7
I share my work reports with other team members							
I share my official documents with other team members							
I provide my manuals for my team members							
I provide my methodologies for my team members							
I share my experience from work with other team members							
I share my know-how from work with other team members							

9. **Please answer the following regarding your opinion about your general attitude toward applying your knowledge in your work. Knowledge Application**

	1	2	3	4	5	6	7
I apply knowledge learned from experience.							
I use knowledge to solve new problems.							
I apply knowledge to solve new problems.							

10. **Please rate how much you agree or disagree with the following statements: Individual performance**

	1	2	3	4	5	6	7
My deliverables are of excellent quality.							
I manage time effectively.							
I meet important deadlines on time.							

11. **Please rate how much you agree or disagree with the following statements: Team Performance**

	1	2	3	4	5	6	7

The team's deliverables were of excellent quality.							
The team managed time effectively.							
The team met important deadlines on time.							

12. You are

□ Male □ Female

13. Age

- ☐ Less than 18
- ☐ 18 through 25
- ☐ 26 through 35
- ☐ 36 through 45
- ☐ 46 through 55
- ☐ 56 through 65
- ☐ 65 and over

14. Tenure on the present job

- ☐ Do not have a job
- ☐ 1 year or less
- ☐ 2 through 5 years
- ☐ 6 through 10 years
- ☐ 11 through 20 years
- ☐ 21 through 30 years
- ☐ 31 and more years

15. Marital status

- ☐ Living with somebody (partner and/or children)
- ☐ Single

16. Have a job

- ☐ Yes
- ☐ No

17. Education

- ☐ No degree
- ☐ Professional education degree
- ☐ Junior college (License)
- ☐ Bachelor degree
- ☐ Engineering
- ☐ Other Master's degree
- ☐ Doctorate

18. Work hours/week on your current job

- ☐ Do not have a job
- ☐ ≤20
- ☐ 21-40
- ☐ ≥45

19. Your occupation in the company/institution/ organization if you are a member of any:

……

I access the main virtual I use: (you can select many)

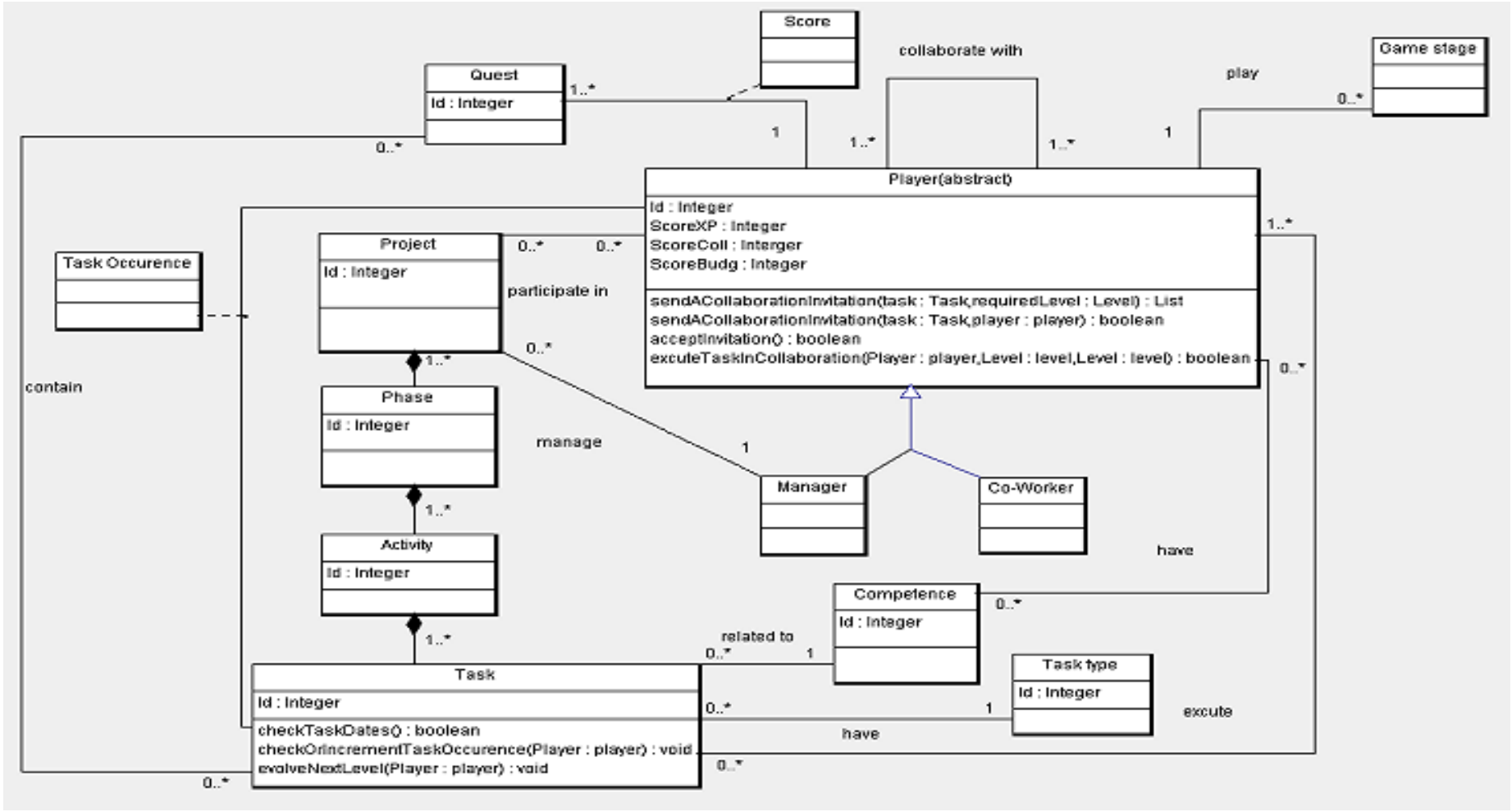
- ☐ On my desktop computer in my job
- ☐ On my desktop computer at home
- ☐ Both (at home and in my job)
- ☐ From a mobile device (iPad, iPhone, Laptop, etc.) at work

- [ ] From a mobile device (iPad, iPhone, Laptop, etc.) at home
- [ ] From a mobile device (iPad, iPhone, Laptop, etc.) at both (work and home)
- [ ] From a mobile device Anywhere else
- [ ] In public internet stationary
- [ ] Other: ……

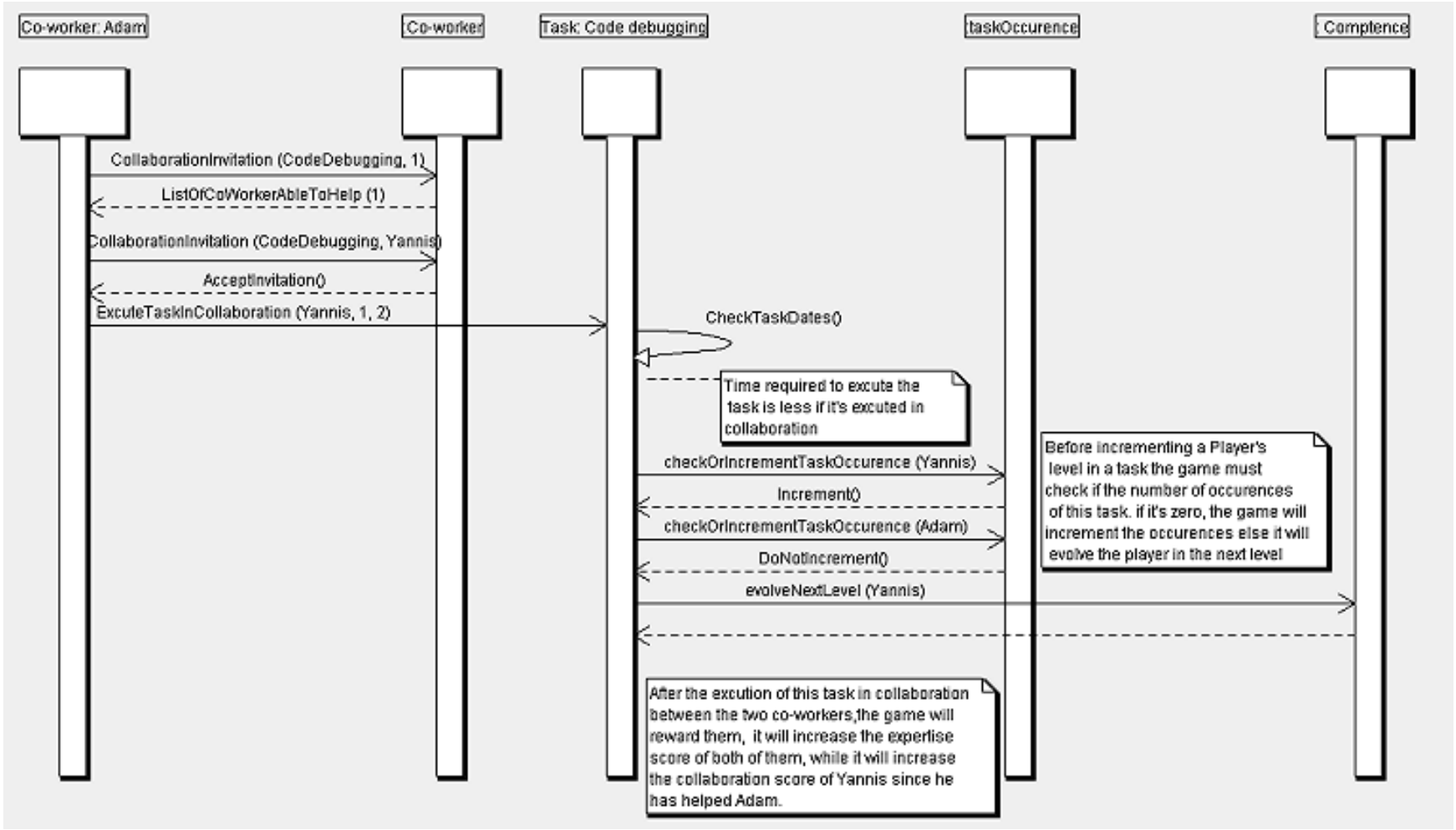
Appendix 12: Cross loadings

	CU	K.A	K.S	O.M	S.L
CU 1	**0.9508**	0.4707	0.3578	0.5760	0.2051
CU 2	**0.9169**	0.4292	0.2918	0.4871	0.1700
CU 3	**0.9644**	0.4478	0.3487	0.4849	0.1437
CU 4	**0.9056**	0.4735	0.4341	0.5436	0.1557
CU 5	**0.9047**	0.3278	0.2969	0.6003	0.1356
CU 6	**0.9112**	0.3343	0.2906	0.5844	0.1393
K.A 1	0.4173	**0.9723**	0.5287	0.3463	0.2862
K.A 2	0.4578	**0.9884**	0.4890	0.3778	0.2237
K.A 3	0.4634	**0.9865**	0.5136	0.3693	0.1934
K.S 1	0.2597	0.4936	**0.8962**	0.3394	0.3050
K.S 2	0.2379	0.4346	**0.8209**	0.2679	0.3326
K.S 3	0.3930	0.4039	**0.8967**	0.3617	0.2712
K.S 4	0.3546	0.4746	**0.8996**	0.3611	0.2176
K.S 5	0.3778	0.4743	**0.9078**	0.4435	0.2154
K.S 6	0.3596	0.4902	**0.9157**	0.4148	0.2636
O.M 1	0.5170	0.3141	0.3060	**0.8619**	0.1806
O.M 2	0.5287	0.3242	0.3918	**0.8143**	0.1629
O.M 3	0.6212	0.3277	0.3796	**0.8314**	0.2561
O.M 4	0.5262	0.3056	0.3472	**0.9141**	0.1532
O.M 5	0.4370	0.2729	0.3256	**0.9050**	0.2004
O.M 6	0.3839	0.3148	0.3477	**0.8434**	0.1605
O.M 7	0.4909	0.3537	0.3520	**0.8223**	0.1882
S.L 1	0.1505	0.1994	0.1840	0.0929	**0.7533**
S.L 2	0.1007	0.1028	0.2222	0.1840	**0.7788**
S.L 3	0.2848	0.2656	0.2284	0.1438	**0.6930**
S.L 4	0.1229	0.1370	0.2066	0.1491	**0.6957**
S.L 5	0.1857	0.2675	0.2649	0.1113	**0.7899**
S.L 6	0.0187	0.1590	0.2018	0.1450	**0.6500**
S.L 7	0.1289	0.2033	0.2114	0.1585	**0.7905**
S.L 8	0.0344	0.1673	0.1702	0.2100	**0.7600**
S.L 9	0.1682	0.1309	0.2429	0.2268	**0.8119**
S.L 10	0.0919	0.1473	0.2743	0.2091	**0.8369**

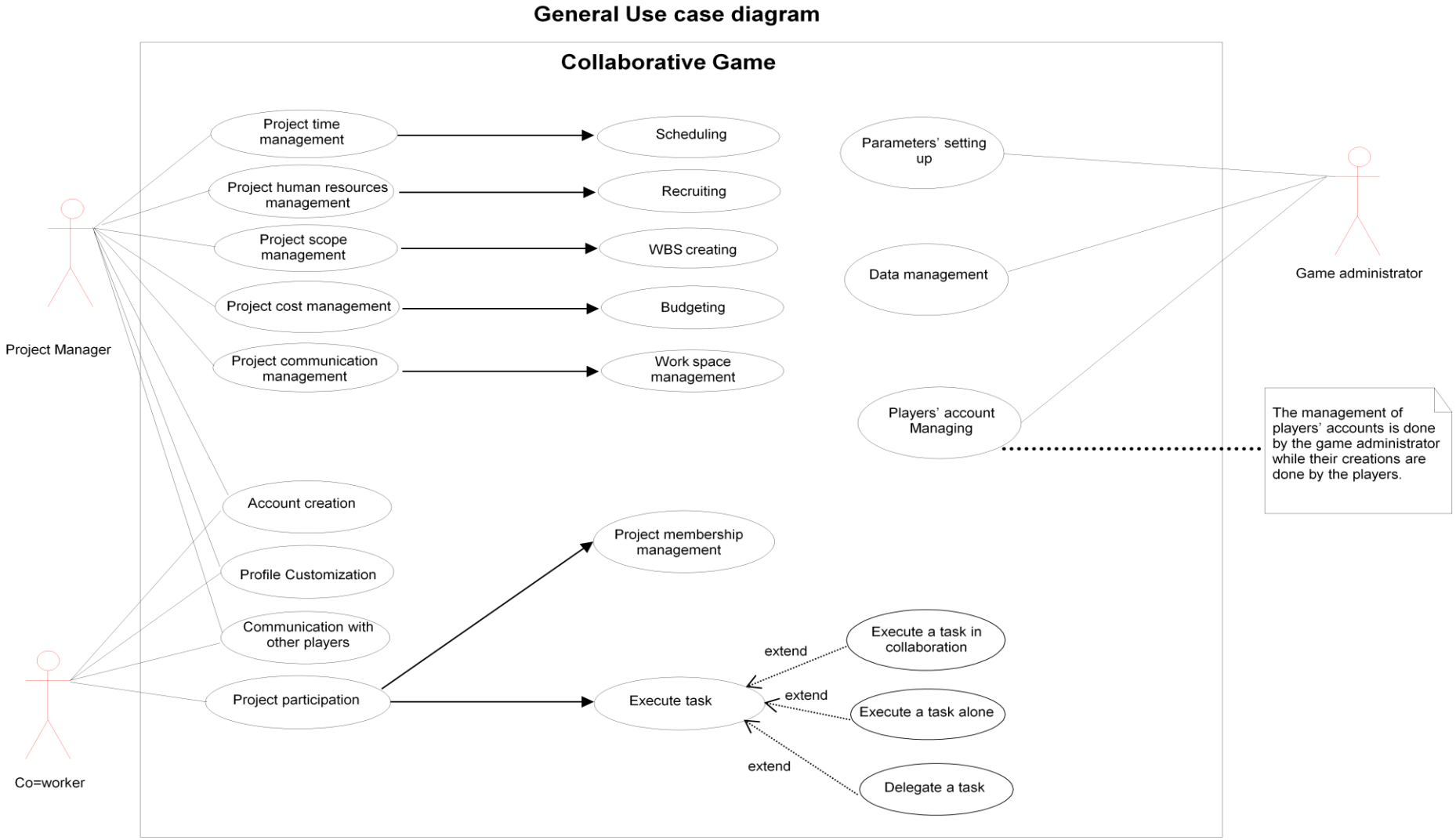
Appendix 13: Class diagram of the game



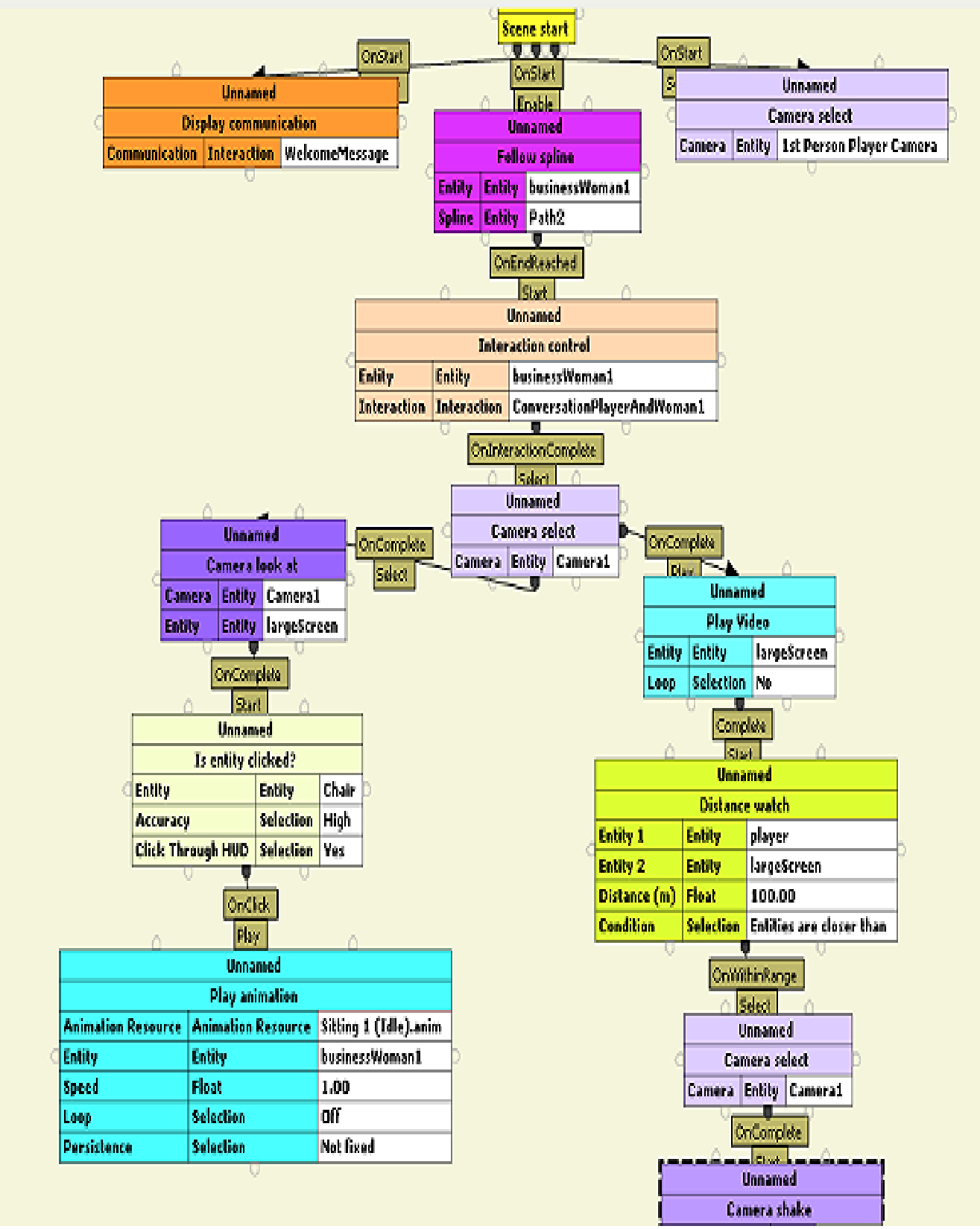
Appendix 14: Sequence diagram: execution of a task in collaboration between teammates



Appendix 15: General use case diagram

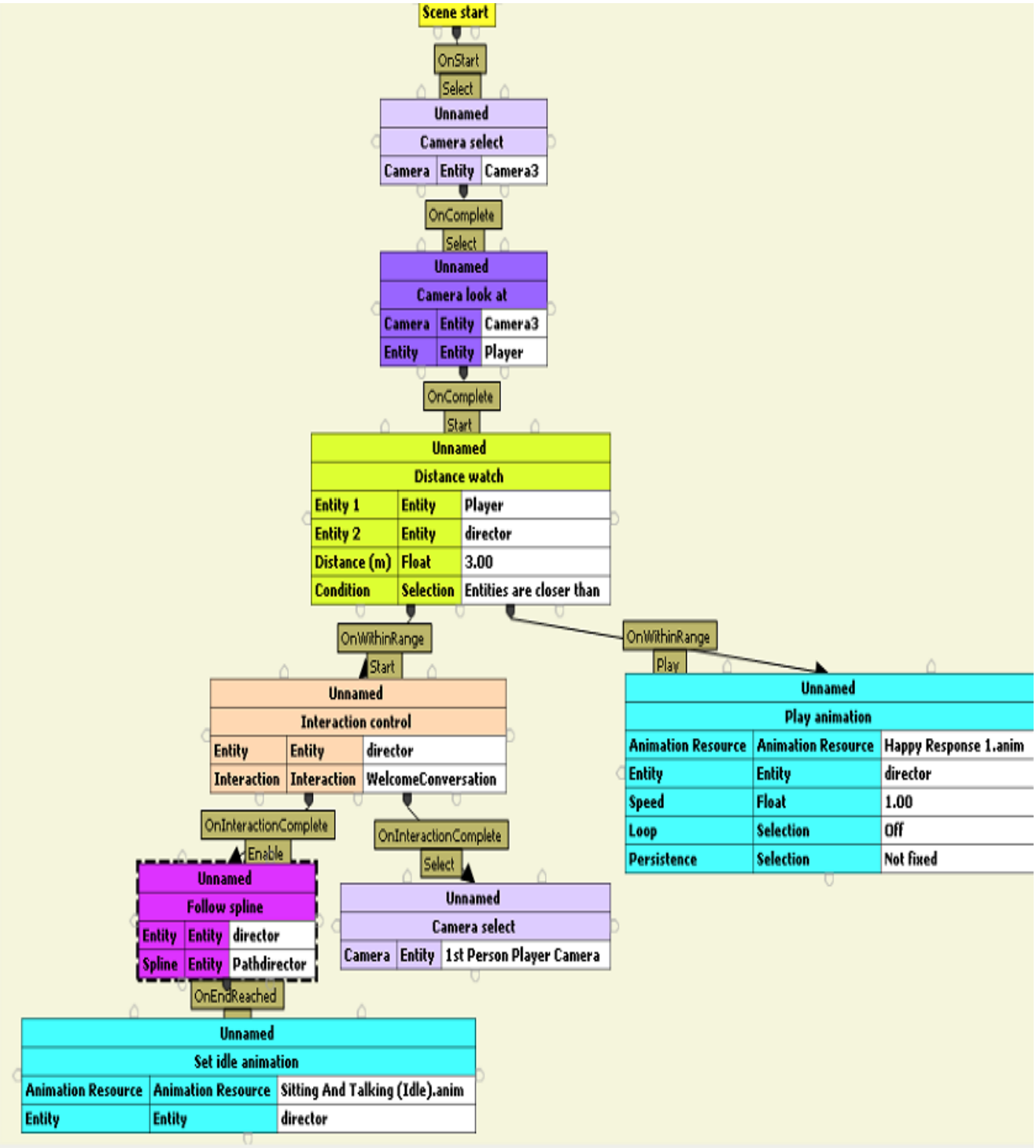


Appendix 16: Scene describing a communication between two teammates

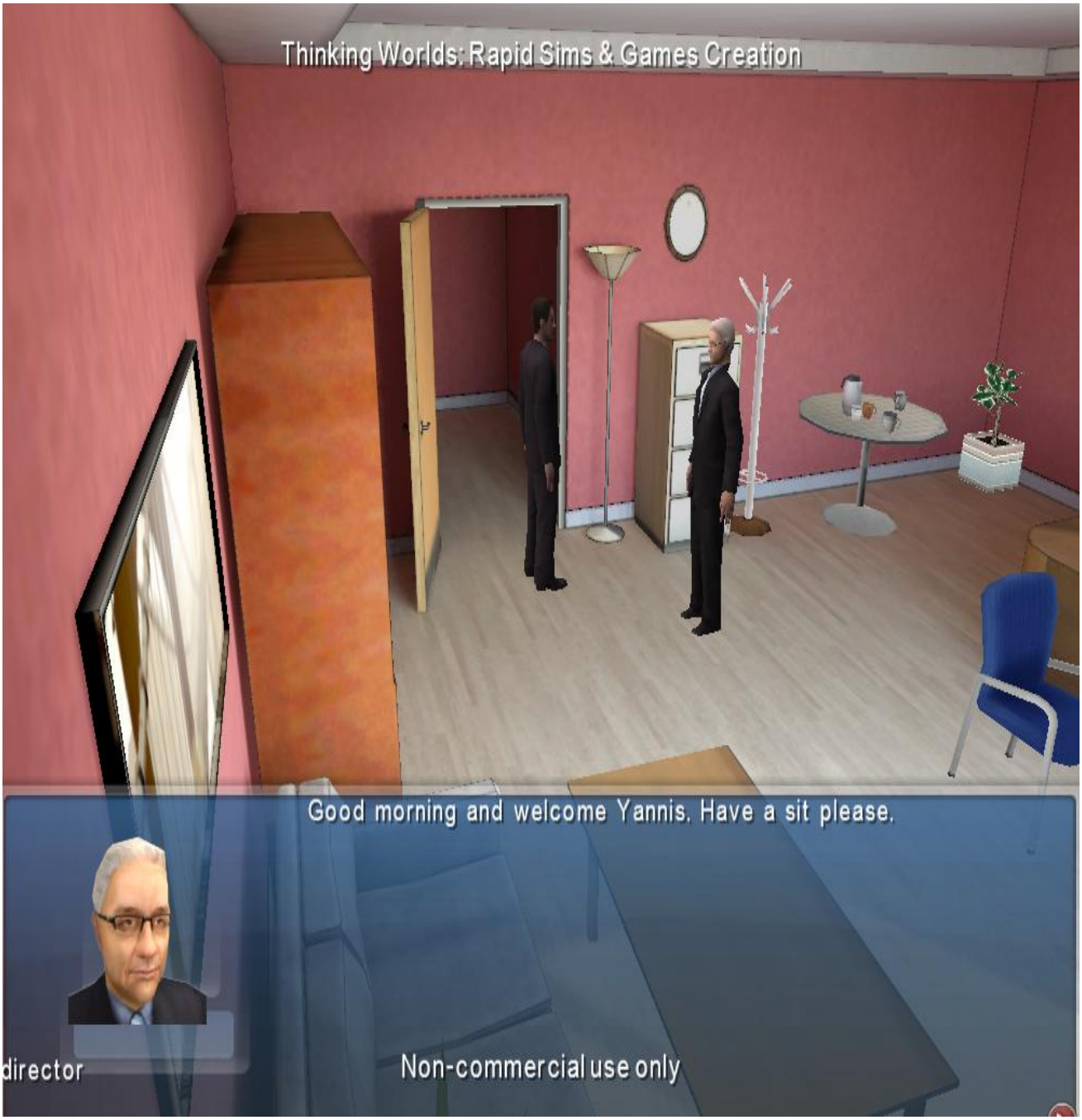


A screen shot of the scene

Appendix 17: Scene describing a communication between a Project manager and a teammate

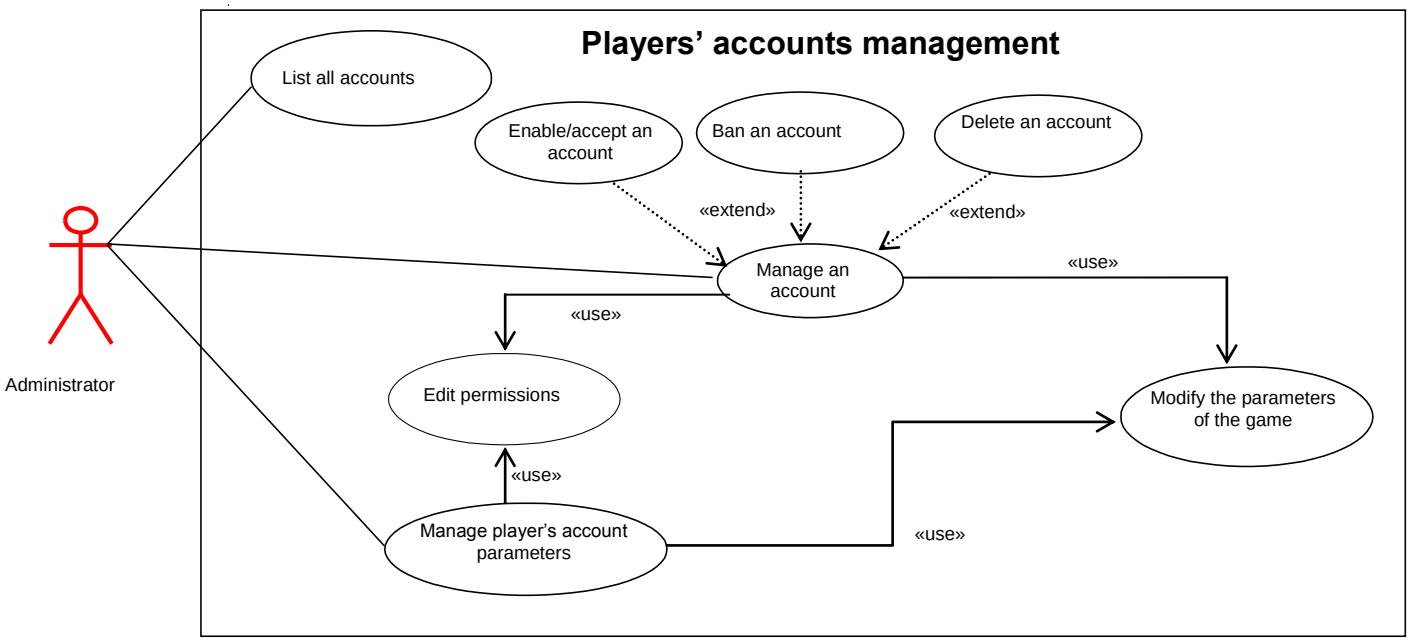


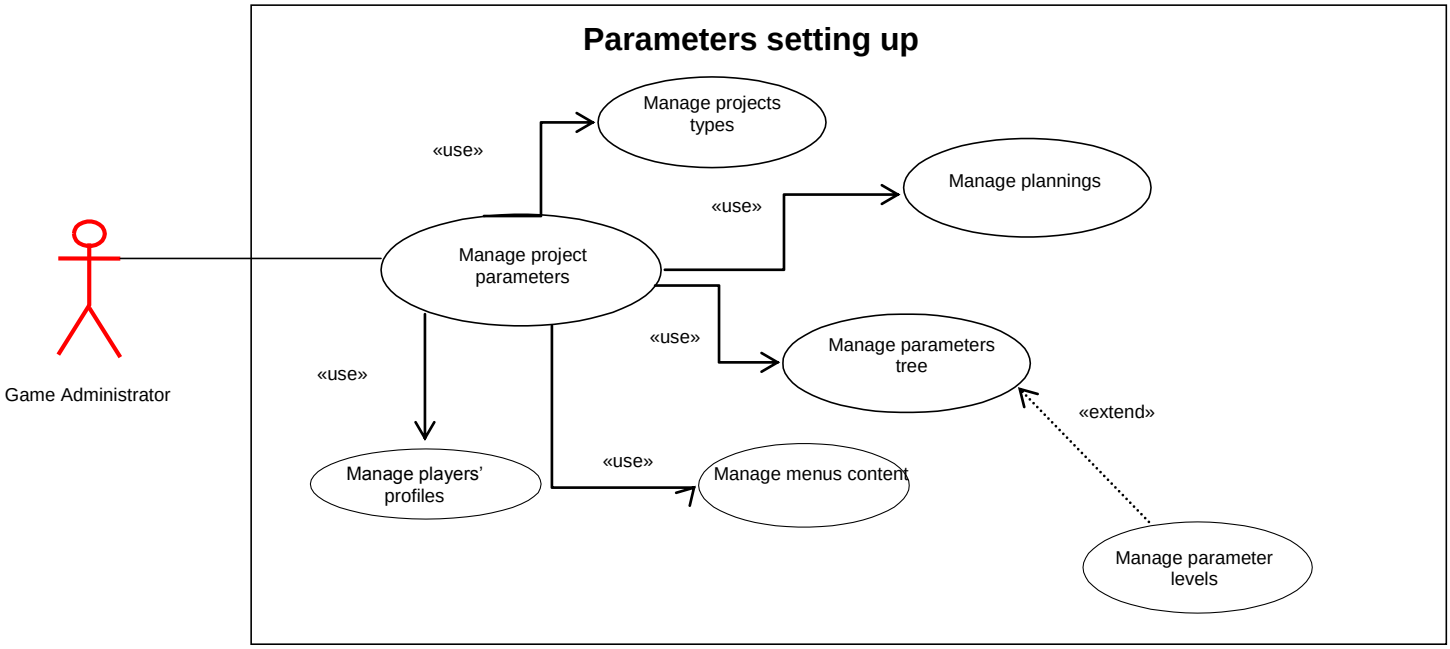
A screen shot of the scene

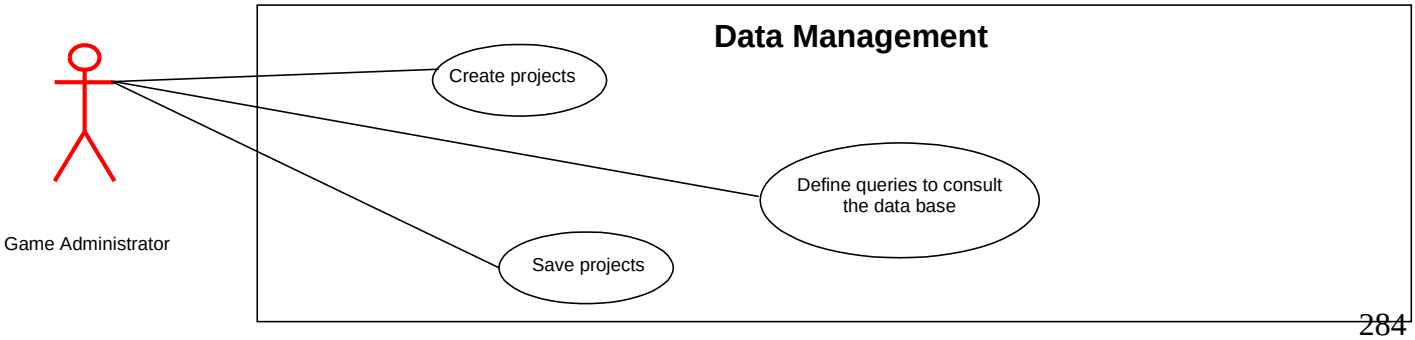


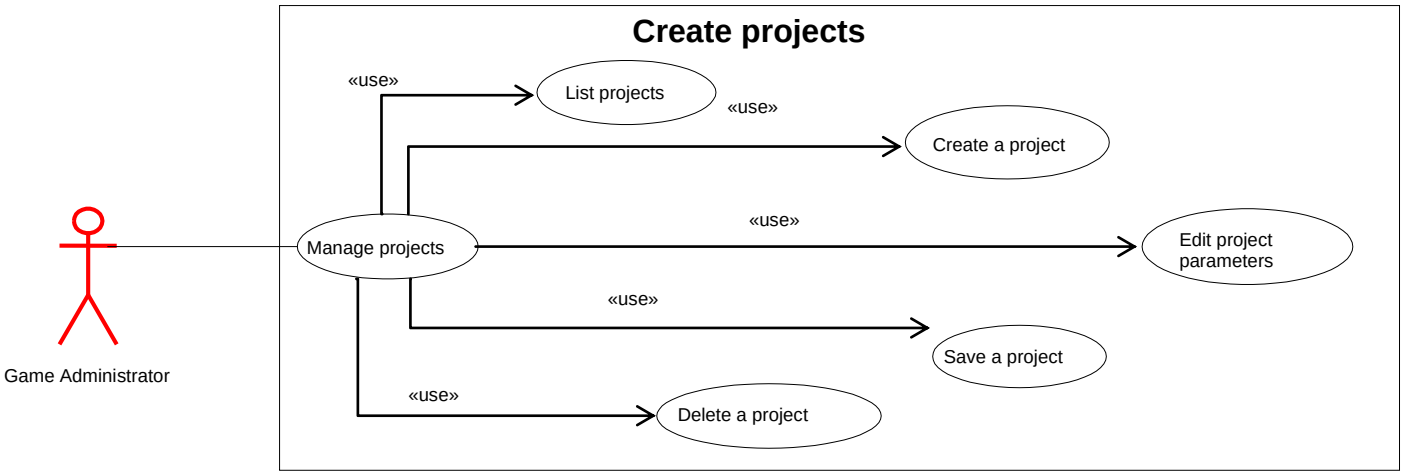
Appendix 18: The game specifications: use cases diagrams

Game administrator

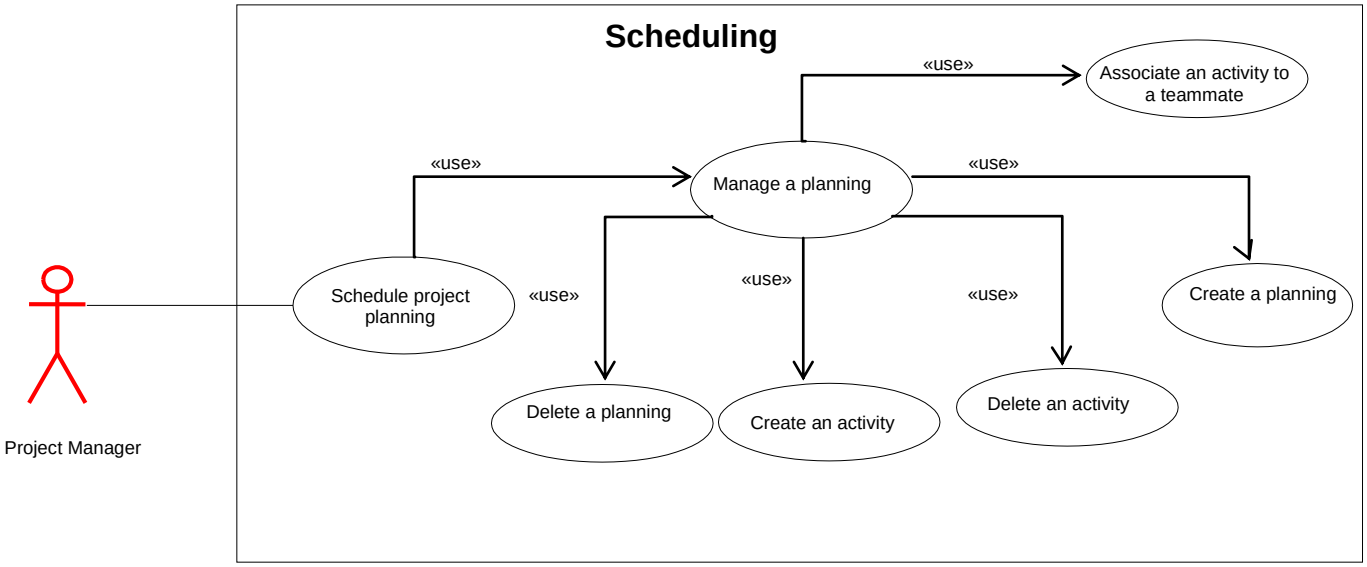


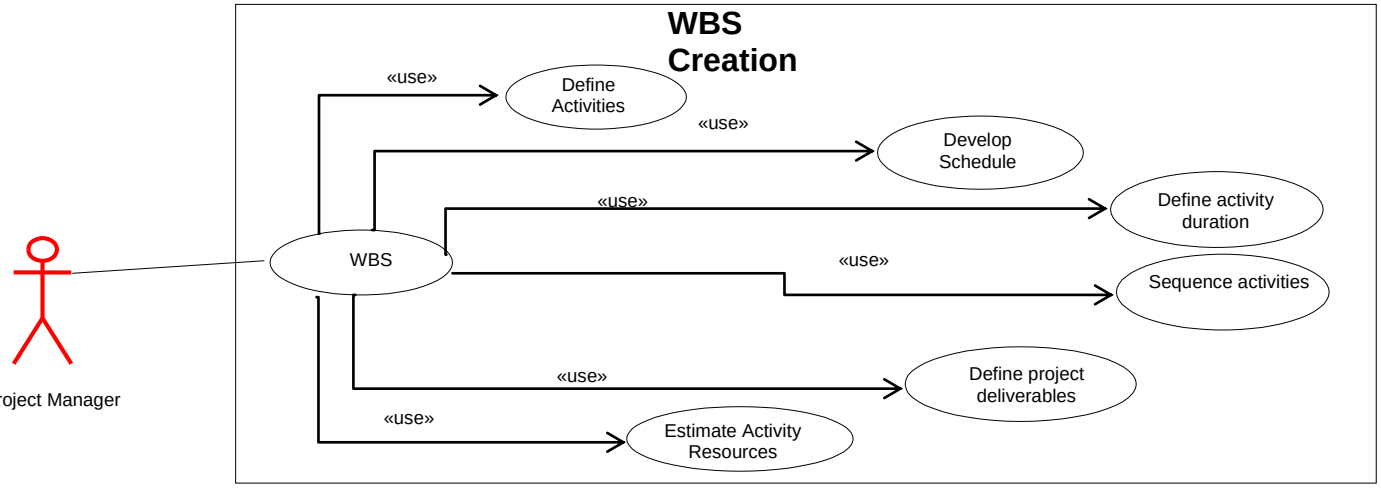


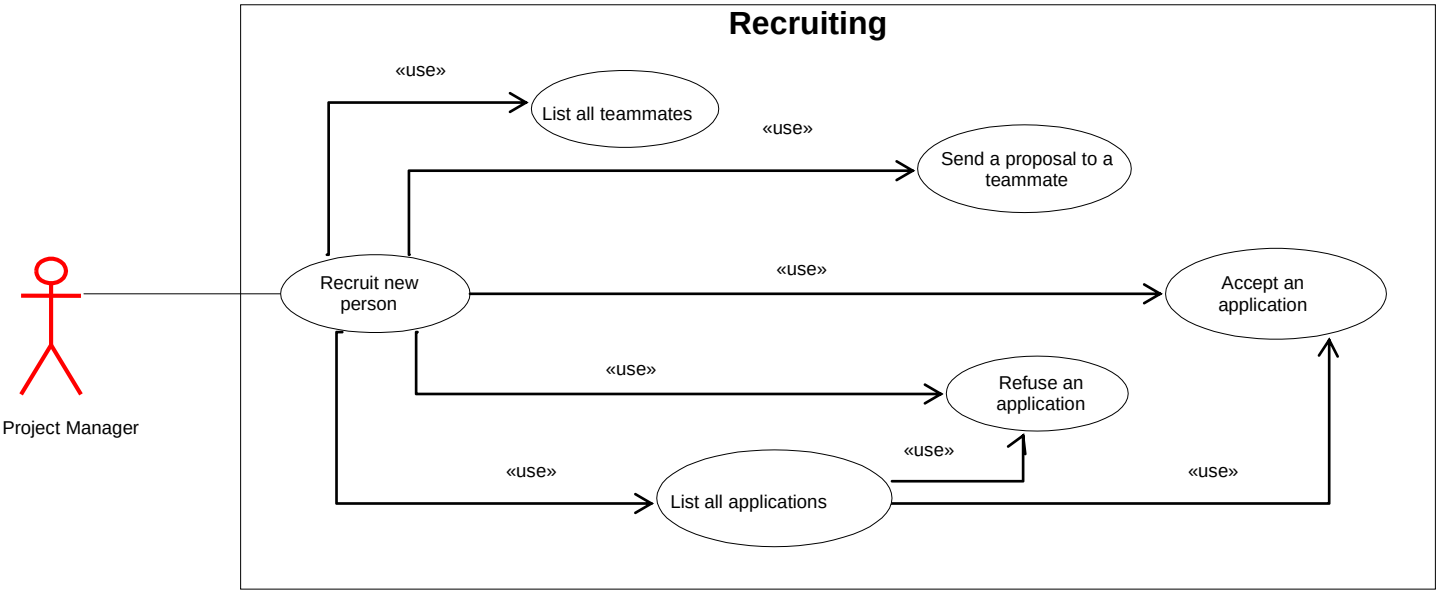


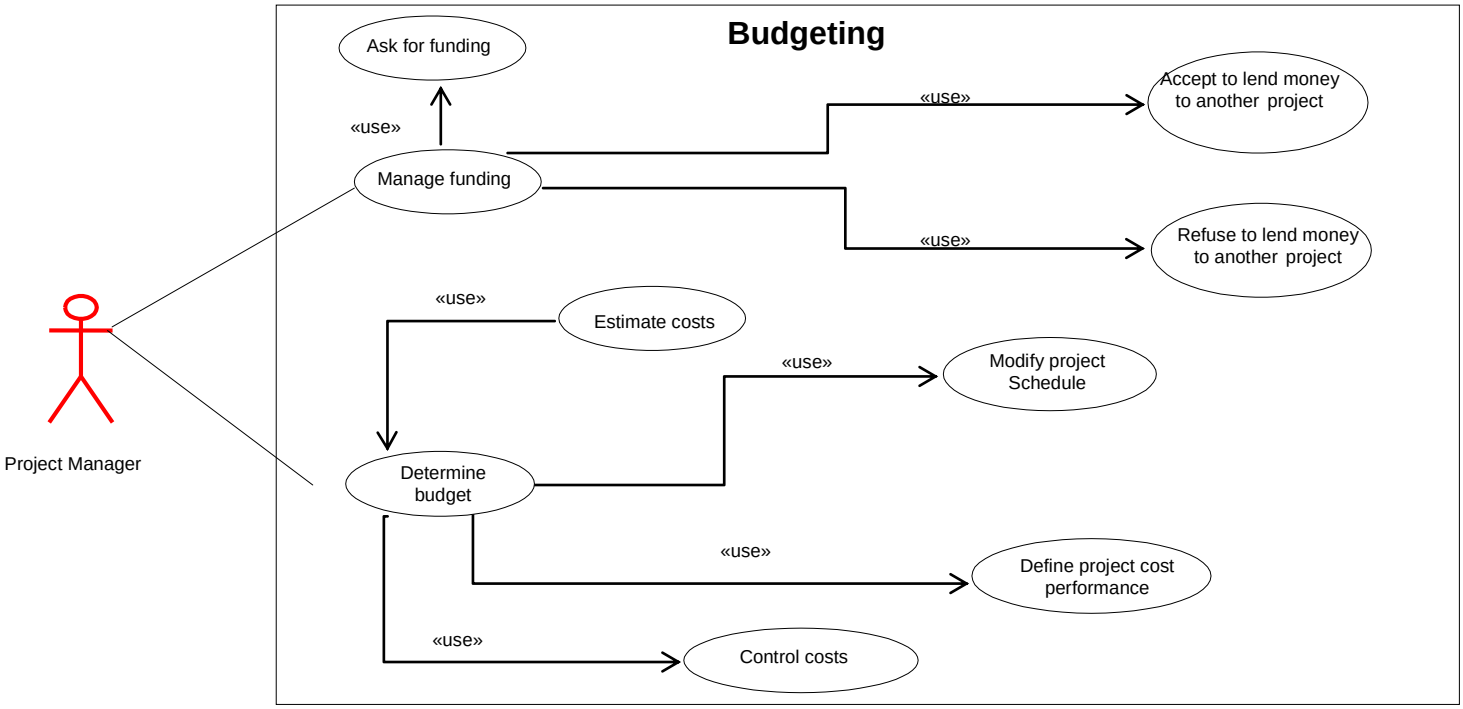


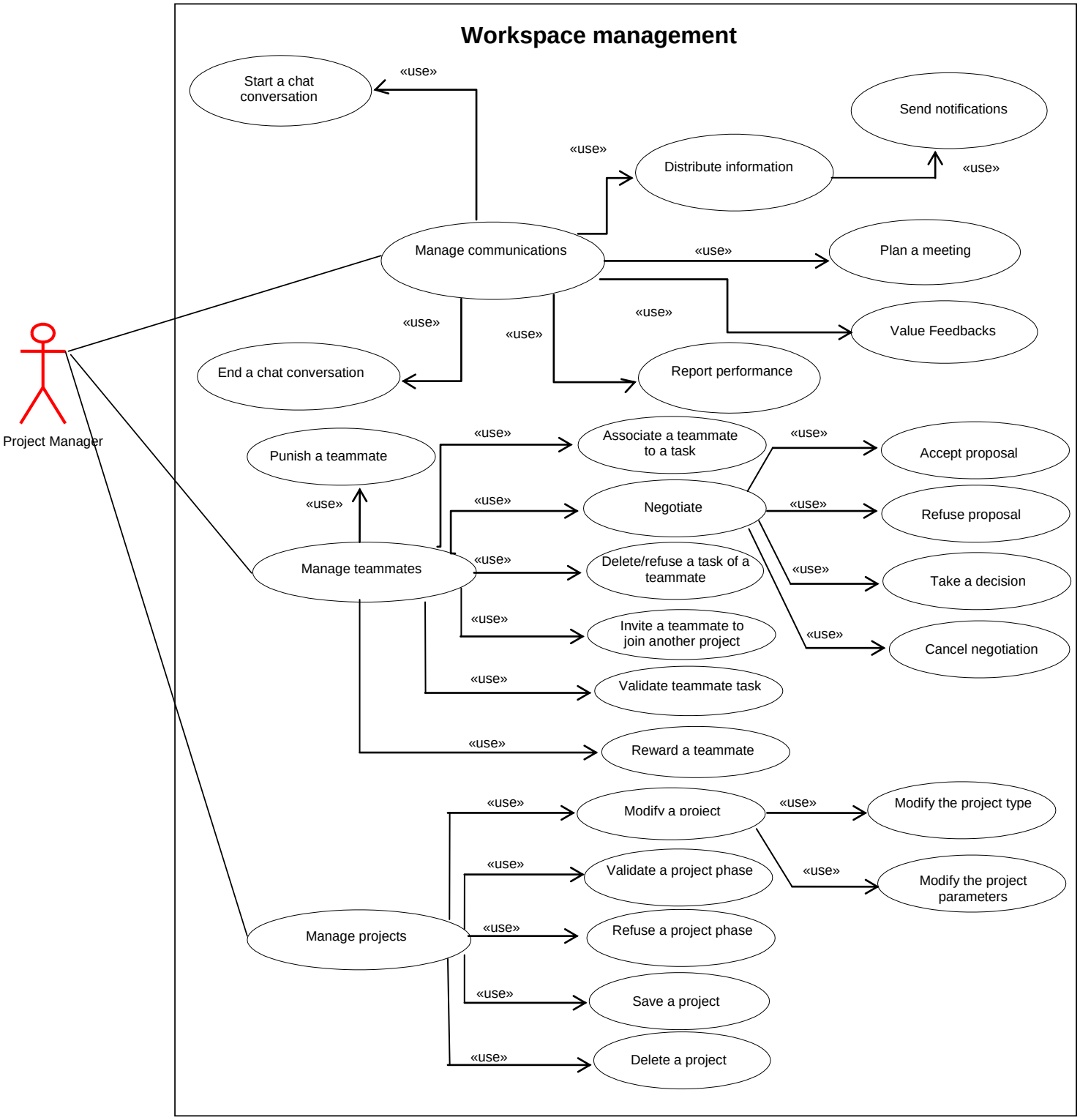
Project Manager

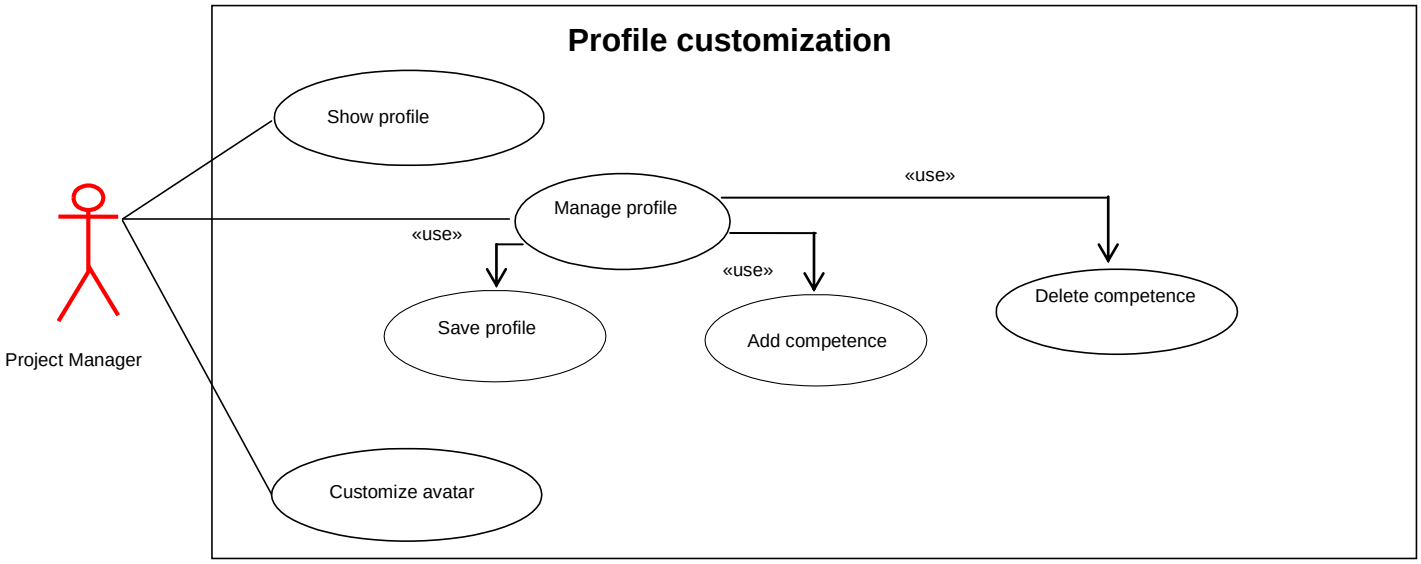


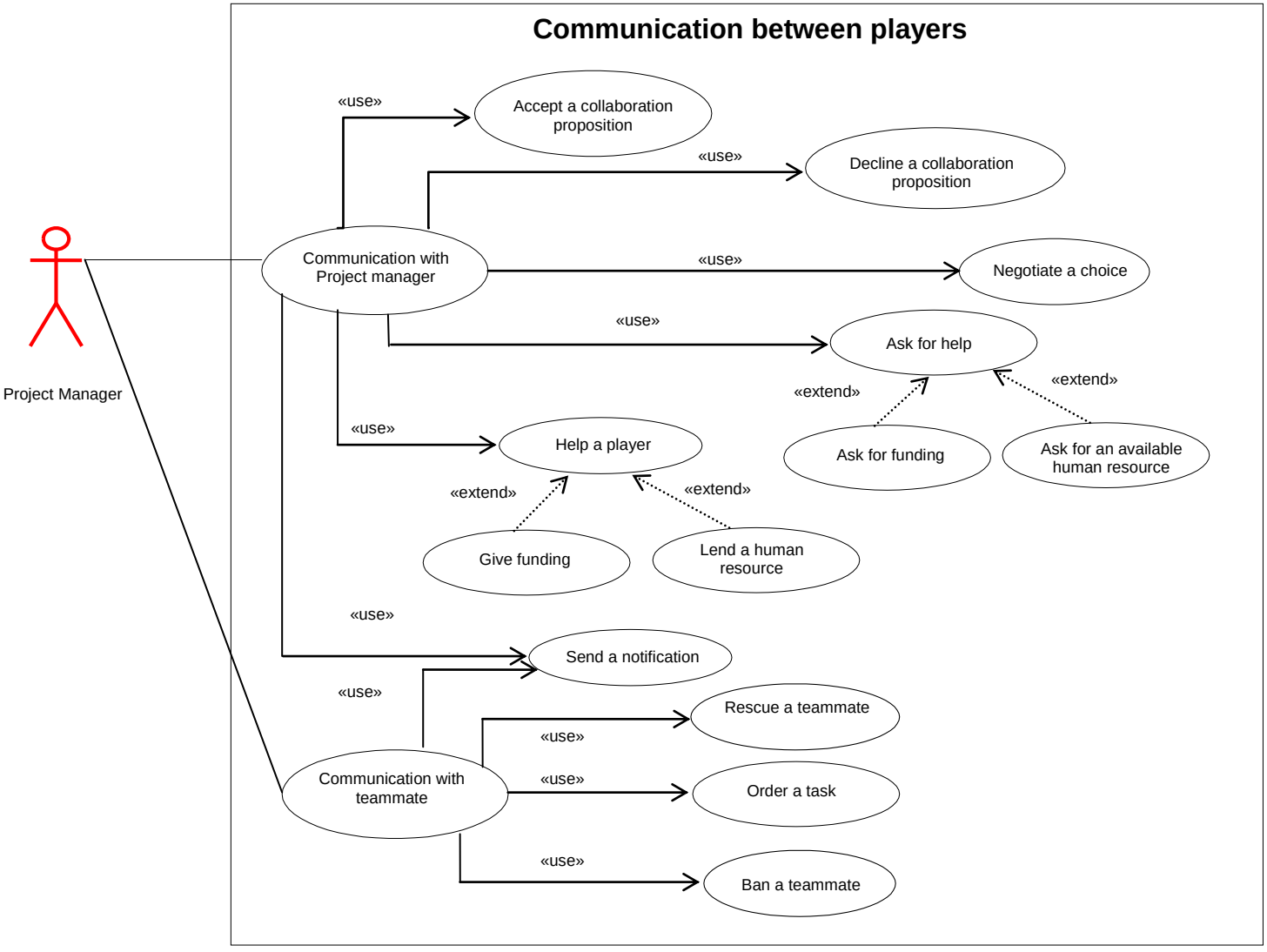



Recruiting
«use»
List all teammates
«use»
Send a proposal to a teammate
Recruit new person
«use»
Accept an application
«use»
Refuse an application
«use»
«use»
List all applications
«use»
Project Manager

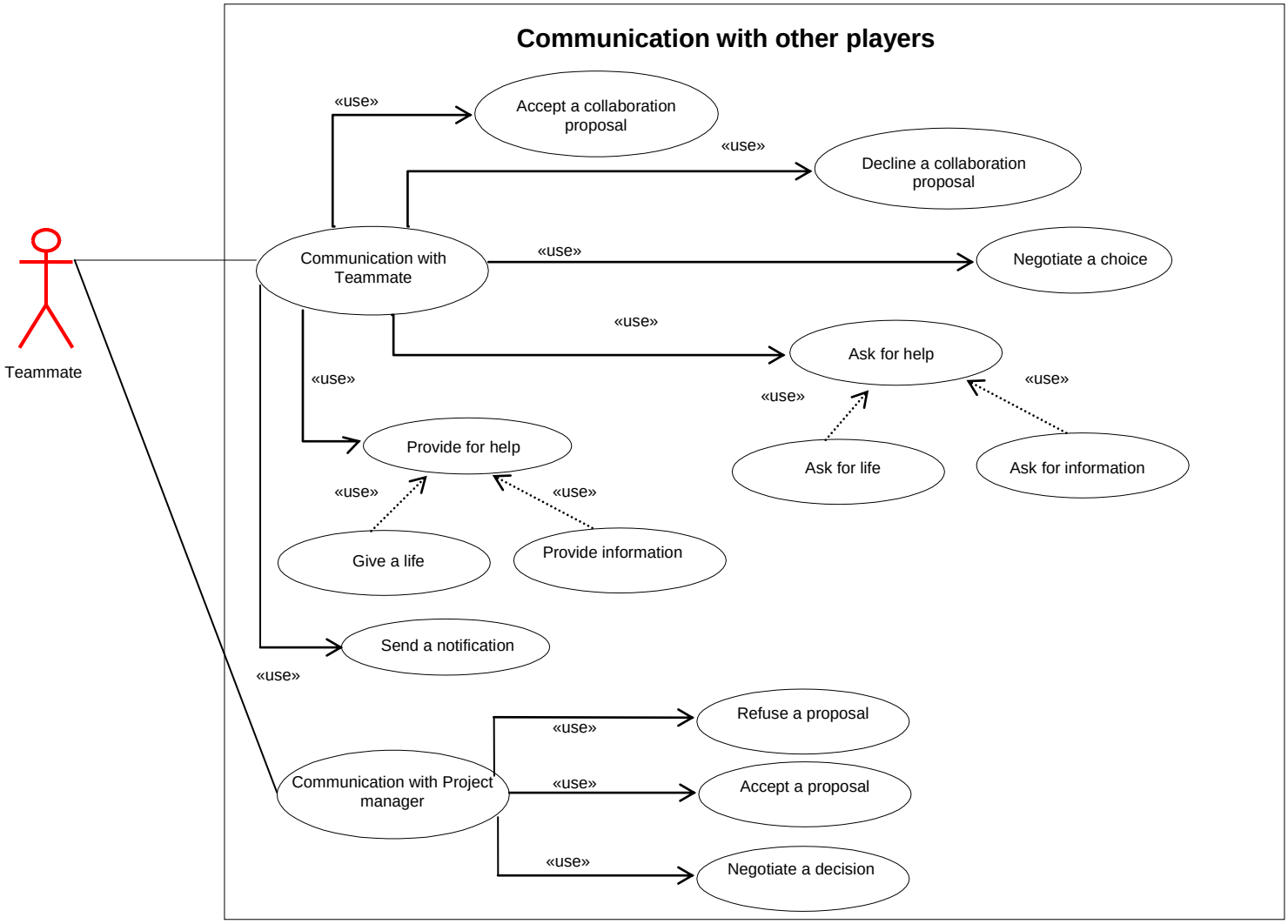

Budgeting
Ask for funding
«use»
«use»
Accept to lend money to another project
Manage funding
«use»
Refuse to lend money to another project
«use»
Estimate costs
«use»
Modify project Schedule
Determine budget
«use»
Define project cost performance
«use»
Control costs
Project Manager

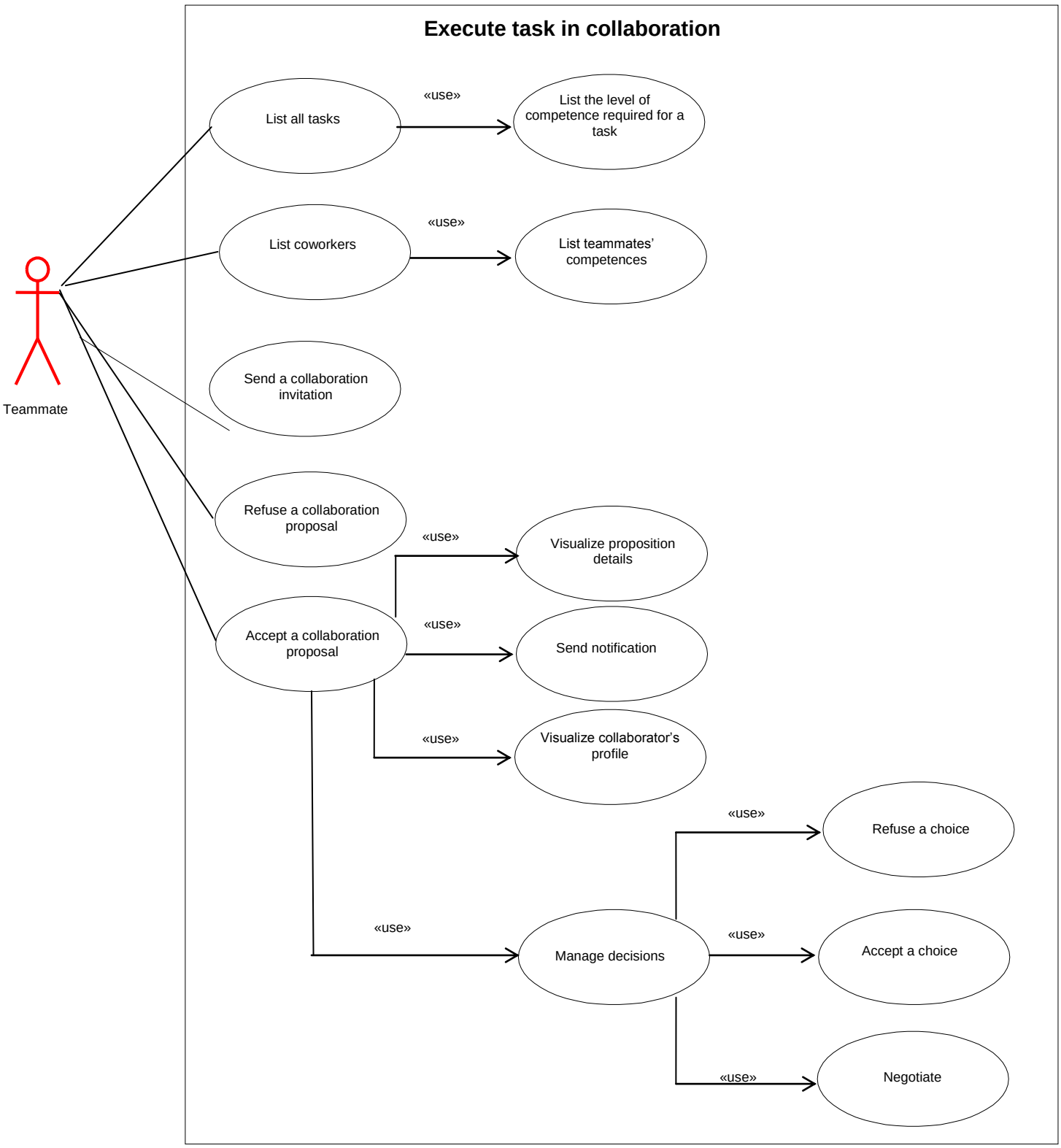

Workspace management
Start a chat conversation
«use»
Send notifications
«use»
Distribute information
«use»
Manage communications
«use»
Plan a meeting
«use»
Value Feedbacks
«use»
«use»
End a chat conversation
Report performance
Project Manager
Punish a teammate
«use»
Associate a teammate to a task
«use»
Accept proposal
«use»
Negotiate
«use»
Refuse proposal
«use»
Manage teammates
«use»
Delete/refuse a task of a teammate
«use»
Take a decision
«use»
Invite a teammate to join another project
«use»
Cancel negotiation
«use»
Validate teammate task
«use»
Reward a teammate
«use»
Modify a project
«use»
Modify the project type
«use»
Validate a project phase
«use»
Modify the project parameters
Manage projects
«use»
Refuse a project phase
«use»
Save a project
«use»
Delete a project


Profile customization
Show profile
Manage profile
Save profile
Add competence
Delete competence
Customize avatar
Project Manager
«use»
«use»
«use»


Communication between players
Accept a collaboration proposition
Decline a collaboration proposition
Communication with Project manager
Negotiate a choice
Ask for help
Ask for funding
Ask for an available human resource
Help a player
Give funding
Lend a human resource
Send a notification
Rescue a teammate
Communication with teammate
Order a task
Ban a teammate
Project Manager
«use»
«extend»

Teammate


Communication with other players
Teammate
Communication with Teammate
Accept a collaboration proposal
Decline a collaboration proposal
Negotiate a choice
Ask for help
Ask for life
Ask for information
Provide for help
Give a life
Provide information
Send a notification
Communication with Project manager
Refuse a proposal
Accept a proposal
Negotiate a decision
«use»


Execute task in collaboration
Teammate
List all tasks
«use»
List the level of competence required for a task
List coworkers
«use»
List teammates' competences
Send a collaboration invitation
Refuse a collaboration proposal
«use»
Visualize proposition details
Accept a collaboration proposal
«use»
Send notification
«use»
Visualize collaborator's profile
«use»
Refuse a choice
«use»
Manage decisions
«use»
Accept a choice
«use»
Negotiate

ABBREVIATIONS

AIS	: Association for Information Systems
CSCW	: Computer Supported Co-operative Work
F2F	: Face-to-face
GSS	: Group Support Systems
ICT	: Information and Communication Technology
IS	: Information System
KM	: Knowledge Management
KMS	: Knowledge Management Systems
KE	: Knowledge Engineering
LOL	: League Of Legends
MIS	: Management Information Systems
MMOG	: Massively-Multiplayer Online
MMORPG	: Massively-Multiplayer Online Role-Playing Game
PLS	: Partial Least Squares
S2S	: Screen-to-screen;
SEM	: Structural Equation Model
SG	: Serious Game
SVW	: Social Virtual World
TAM	: Technology Acceptance Model
UTAUT	: Theory of Acceptance and Use of Technology
VW	: Virtual World
VWPM	: Virtual World Project Management
WOW	: World Of Warcraft

KEYS TERMS AND DEFINITIONS

Behavioral-science paradigm	: "*aims to explain and predict phenomena related to the identified business need through the development and justification of theories*" (Hevner, March et al. 2004, p.75).
Collaboration Engineering	: "*The whole of concepts, methods and techniques allowing analyzing, designing, setting up and upgrading information systems to support any collaborative activity in adequacy with needs and requirements of its users. This engineering allows contributing to Collaboration Knowledge Management within the various working groups*" (Boughzala, 2007)
Collaboration or collaborative work	: derives from the Latin *com* and *laborare* to labor together; it can be defined as making a joint effort toward a common goal (Briggs, Vreede et al. 2003). : "*A social phenomenon that involves several individuals when the action of only one does not achieve the expected result*" (Levan 2004, p. XIII).
Collaboration Science	: "*The study of individual, group, organizational, and societal factors affecting outcomes for people who work together to achieve goals*" (CCS)
Design-science paradigm	*: "seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts*" (Hevner et al. 2004, p.75).
Generation Y	: A new generation of younger, college- and university-educated workers born between 1978 and 1995 and grown up with the Internet – also called Digital Natives or Milennials.
Knowledge Management	: "*is a discipline of enabling individuals, teams and entire organizations to collectively and systematically create, share and apply knowledge, to better achieve the business objectives*" (Mentzas 2004) p116.
Knowledge Sharing	: "*Activity involving beliefs, feelings, values and dispositions to share particular knowledge with particular people.*" (Boughzala and Briggs 2011) p. 22.
Serious games	: "*A serious game is a game in which education (in its various forms) is the primary goal, rather than entertainment*." (Michael and Chen 2006)p 17
Virtual work	: Work should not "*be considered virtual* (only) *when all interactions were mediated by distance, with no work completed in face to face mode*", but "*along a continuum with variations in the extent of face-to-face*" and screen-to-screen work (Chudoba et al. 2005) , p.281.
Virtual world	: *"Is an instantiation of a metaverse—a fully immersive 3D virtual space in which people interact with one another through avatars and software agents"* (Owens et al. 2009).
Virtuality or virtualness	: The extent to which a process can be virtualized (Martins et al. 2004) – to move from Face-to-Face collaboration to e-collaboration.
Web 2.0	: The second generation of web development and design based on social software – also called Social Media.