

Social Awareness: The Power of Digital Elements in Collaborative Environment

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Abstract: - Awareness is the sense of what is happening, who is around, what they are doing, what their states of emotion and whether or not they notice you. Social awareness and how they are promoted by digital elements in networked collaborative virtual environment (NCVE) is the main focus of this study. Social awareness is defined as the understanding of a contextual situation at a present time. In networked collaborative virtual environments (NCVE), awareness plays an important role for achieving an effective digital communication. For a particular virtual environment, participants should be aware of the people whom they are interacting with, their responsibilities and contributions, the collaborative activities and their progress level. This paper discusses the digital elements that are used to support awareness during virtual collaboration by exploring their characteristics and the differences in terms of their specific roles in promoting awareness. With the main focus on social awareness, eight different awareness types (presence, turn taking, emotion, identities, state, role, contextual and conversational) are presented with respect to these digital elements. The impacts of using each digital element in various applications are also identified in order to enhance the usage of these elements when they are applied to their relevant networked collaborative applications. Thus, with appropriate use of digital elements, awareness in such situation can be improved.

Key-Words: - Networked Collaborative Virtual Environment (NCVE), Awareness, Digital elements, Social awareness, Communication, Interactive collaborative applications.

1 Introduction

Internet has change the way we live our daily life. We shop from home, we do our banking transactions online without having to go to the bank and we liaise with our business partners through our e-business system. A new way of socializing has emerged; we hang out, seek advice and share our lives with buddies that we never set eyes before. Virtual office offers means to adapt ourselves to an alternative way of working from disperse locations with differences in ethics, cultures and backgrounds. E-learning offers students to exchange knowledge and cultures with virtual classmates from all over the world without having to leave their countries and incurring more cost.

Networked collaborative virtual environment (NCVE) enables people to work together as a group via internet, even when they are at different physical locations. NCVE support video conferencing, instant messaging, bulletin board, audio-video chatting and game as a new way of socializing, working, learning and entertainment. The potential of NCVE is undeniably

great.

While working together, users need to communicate, coordinate and cooperate [1] as though they are in face to face situation. In this situation, verbal and non-verbal communications happen easily and naturally. It is undeniably that an effective human communication does not solely involve verbal communication. It includes other non-verbal communication cue and body language like gestures, body postures, facial expressions, direction of gaze [2] and also influenced by physical appearance such as how people look and dress. Moreover, communication is greatly affected by communication cues that people receive, but they overlook the details of the cues. There are times that body languages speak louder than the voices. Naturally, in the face to face communication, people are aware of verbal and non-verbal communication without difficulty.

Despite the importance of non-verbal communication cues for effective communication, the cues are usually missing or lacking in NCVE system. As a result, there exists unnatural communication and degrading quality in

virtual collaborative communication [3]. Nova *et al.* [4] prove that players in a collaborative game perform better when awareness tools are used. Players are aware of the action and intention of team members as well as opponents which result in better communication and strategy formulation while in the game.

This paper is organized as follows: Section 2 discusses on the related work of networked collaborative environment, awareness and how it affects communication. Section 3 presents the comparative study on several digital elements (text, 2D graphic, 3D avatars and audio-video) with respect to awareness types and collaborative applications, before the concluding remarks in Section 4.

2 Related Work

Much research has been undertaken to explore the usage of the internet in multi-disciplinary areas including education [5-7], entertainment [4,3,8], business [9-11] and many more. When using the internet, users involve in communication that requires means of presentation to emerge themselves in virtual environment. Therefore, awareness plays an important role in providing the means. Researchers focus on vast aspects of awareness ranging from social awareness (who is present in the virtual space), action awareness (what is happening in the virtual space) and activity awareness (why does it happen) [5]. In terms of sharing data and artifacts, some areas of the interest are asynchronous awareness (different place, different time) and synchronous awareness (different place, same time) [12]. Synchronous awareness is being explored further into tight synchronous based on "What You See is What I See" (WYSIWIS) model [9] and loose synchronous where users in the same virtual space can work together on a different screen or different part of the same screen privately [13].

2.1 Networked Collaborative Environment

Networked Collaborative Virtual Environment (NCVE) allows people from various locations to engage in common activities interactively and remotely via computer networks as though they are working in a face to face environment [14]. NCVE involves more than just simple chatting between users in a virtual space but also involves other activities including sharing of resources during collaboration. Shared resources could be in any multimedia forms such as text messages, text document, 2D graphics, 3D graphics, audio as well as videos. Users can directly manipulate these resources and any changes made to the resources could be viewed by all collaborators in the virtual space immediately. The ease of viewing the control of resources leads to the issue of privacy [13]. Some users are uncomfortable with the

situation as their actions are transparent and freely viewed by others. They would like to have an exclusive control over the resources or be invisible to others whenever they choose to be. It is still a debatable issue to balance between privacy and privilege over shared resources [13].

NCVE has slowly changed the way people do things as it is cheaper to collaborate online without any traveling cost and save the precious time. NCVE can also increase productivity and promote knowledge as people can easily share and exchange information among themselves [14]. It also offers enjoyment and entertainment when people get together to play games [14]. Various kinds of interactive collaborative games for all ages are available when it was not even possible before.

Currently NCVE is widely used commercially including in banking system, managing finance, system planning, medical system, knowledge management and micropayment system [15]. In teaching and learning, NCVE has allowed students from different countries and ethnic backgrounds to meet and work on the same projects even in the area that involve practical activities such as science projects [16]. This is an opportunity to exchange ideas, cultures and at the same time, improve self-confidence [17] as well as develop students' creative thinking [18].

A successful collaboration requires support from effective tools to ensure smooth interaction, communication, coordination and cooperation. It is vital as far as cost is concern in business world and transfer of knowledge in education. In order to make it a reality, careful and proper selection of suitable digital elements (text, 2D, 3D, audio-video, audio) can determine the success or failure of a virtual collaborative work.

2.2 Awareness and Communication

Many awareness issues that had been addressed in the literature focused on enhancing communication effectiveness in many fields [19-22]. For example, DiMicco *et al.* [19] design and develop a system, called *Second Messenger*, which supports dynamic awareness in order to promote effective communication. The system displays and analyzes participation patterns of speakers in a face to face collaboration. The result of the study indicates that the system has successfully increased collaborators' awareness among speakers and other individuals who are involved in the discussion. The presence of awareness is able to increase participants' interest to get involve and eventually the number of people participated and contributed ideas in the decision-making process increased. Moreover, the findings suggest that awareness facilitates systematic changes in group communication styles and highlights the potential for such applications to improve group

interactions [1].

On the other hand, Ha *et al.* [21] focus on input devices as means of communication. They study the effect of awareness by exploring users' interpersonal interactions during collaboration by using a tabletop display. In other words, their research focuses on the interaction of collaborators in a virtual space by means of stylus, mouse and touch-based devices. In their study, a group of collaborators interact simultaneously by using tabletops. Observations are made on the usage of these input devices and their impact on collaboration. They investigate how these input devices affect natural interactions, ergonomics, territoriality, gestures, and awareness of both intention and action. In term of awareness, the result shows that it is difficult and distracting to keep track of multiple usage of mouse cursors. On the other hand, styli are the best choices to stimulate users' awareness of intentions and actions. One of the users states that it is the position of the stylus that enables him to guess what his partner wants him to do. Moreover, the use of stylus creates less confusion for him to know his collaborators' actions when using multiple input devices. In term of response, users react faster when using touch input devices. Such devices allow easier action trackings among the collaborators. Thus, the environment will implicitly promote higher awareness. This shows that input devices have impact on user's awareness and interaction [21].

Baker *et al.* [22] study awareness issues in human-robot interaction, specifically on urban search and rescue (USAR) robot. The task involves travelling into dangerous and small remote areas to search for survivors. The robots are teleported by means of directions received from operators. In order to execute the task effectively and efficiently, operators are expected to have a high degree of awareness for the robot's environment. Unfortunately, situation awareness is complex and is not easily obtained [23-24]. Many tools such as sensor maps, color videos, infrared (heat detection), sounds, and carbon dioxide are needed to establish such awareness. Some of these tools are attached together to the robots and the rest are within the monitoring system. The communication between collaborators within this system requires group awareness.

Thus, group awareness in NCVE is a crucial issue in virtual communication. It helps users to feel comfortable and natural when communication takes place in a virtual space. This research, perhaps, is the first attempt to study on several digital elements and their support for group awareness. This paper focuses on identifying eight awareness types and how they are supported by the specific usage of digital elements.

3 Comparative Study

In this section, four types of digital elements are identified as follows:

- *Text*: any words and combination of words
- *2D graphical*: any graphical objects with or without simple animation.
- *3D avatar*: any graphical 3D objects embodiment of human and imitate most of human actions.
- *audio-video*: user voice and his/her image in a video form.

Eight awareness types are selected and remodelled as follows:

- awareness of presence [1,6]
 - Number of people logging-in and who are they?
- awareness of turn-taking [1]
 - Whose turn to talk?
 - When is my turn?
- awareness of emotion [1]
 - What my buddy feels right now?
 - Does anyone notice the changes in my emotion?
- awareness of identity [1]
 - What is the background of the person I am associating with?
- contextual awareness [1]
 - What is the progress level?
 - How I progress compared to others?
- conversational awareness [1]
 - Move this to there, do others know what I mean by this and there?
- awareness of state [3]
 - You are logged-in but are you available to communicate?
- awareness of role [3]
 - I am a king and I govern the whole kingdom. Who are you?

This section explores how the four digital elements support the eight awareness types. Several questions to be answered are as follows:

- Can the digital elements support all type of awareness?
- What is the strength of each of the digital elements?
- What would happen if only one digital element is being used in a NCVE application?
- How many digital elements are needed to be applied in any given application to support effective communication?
- What is the strength of the digital elements?

The chosen digital elements are based on their popularity and how they are widely employed in virtual environment as means of communication. They appear

in most of NCVE systems including instant messaging, e-learning, virtual meetings and games. They are categorized into the eight awareness types.

Text which is categorized as verbal communication presents words as the identification and communication. Figure 1 shows a sample screen for a text chatting system. A user can type words on the area provided to convey message to others. The list of messages keep on increasing in length as the communication goes on and it is used as the communication history. Furthermore, it can also be used for a reference or proof of the given instruction. Text is widely used for informal communication like personal chatting and sharing of interest. It is simple and in casual form.

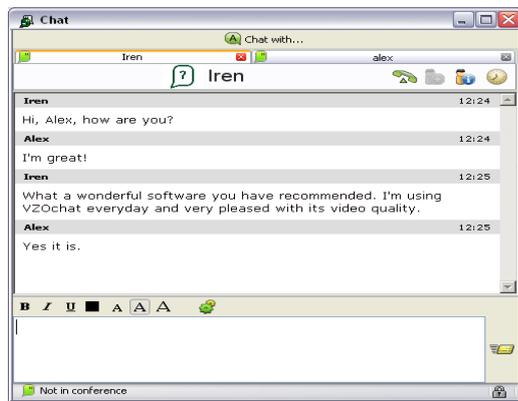


Figure 1: A text chatting system from Vzchat[25]

Unlike text, 2D graphic uses graphical image with colors, shapes and sizes as a medium of communication. The different colors, shapes and sizes, communicate and convey different meanings to users. Figure 2 shows how 2D graphic represents users through their photos along with a small colored circle to indicate positions and roles in the virtual work.

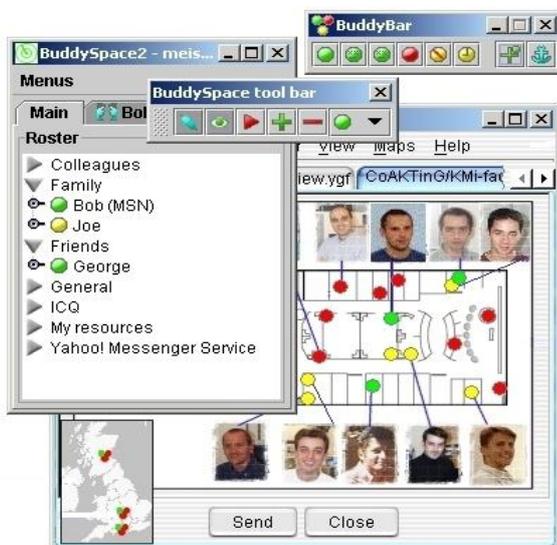


Figure 2: A 2D graphics in a collaborative system [6]

The similar colored circle links the collaborative space to a geographical map to display their disperse demographics. Figure 3 illustrates the example of using different colors, shapes and sizes to represent different users.

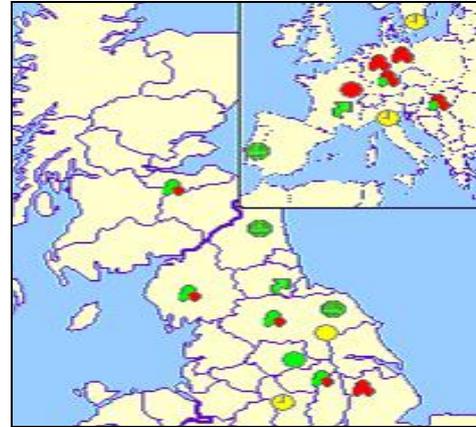


Figure 3: Users' representation on maps [6]

Similarly, 3D avatar employs various shapes, sizes and appearances to represent virtual users. The 3D avatar is a 3D object that embodied human, looks like human and imitates most of human actions as illustrated in Figure 4. The objective of 3D representation is to promote realism during collaboration. In addition, most avatars can transform their appearance dynamically for interesting and exciting scenes especially in collaborative games.

The 2D graphic and 3D avatar are not only represent users but also represent artifacts, resources and background scenes as shown in Figure 3 and Figure 4. However, this paper focuses on 2D graphic and 3D avatar that exclude voice-message which is by itself is another medium of communication and beyond the discussion.



Figure 4: An example of avatars for collaborative game[8].

Audio-video is another form of digital element which involves the usage of camera and audio facilities. Users view each other through screens as their virtual windows. Figure 5 illustrates the use of one window to represent one user or a group of users from the same physical location.



Figure 5: A sample of Vzochat [25] window

When the number of users in the virtual space increases, the number of faces appears on the virtual windows also increases. Even though the computer screen might be overwhelmed with faces, the audio-video media can easily support verbal and non-verbal communication.

3.1 Social Awareness vs. Digital Elements

Since awareness must be supported by some elements during virtual communication, the relationship between such elements need to be modelled. Figure 6 proposes a communication model which includes sender/receiver and message with embedded eight awareness types.

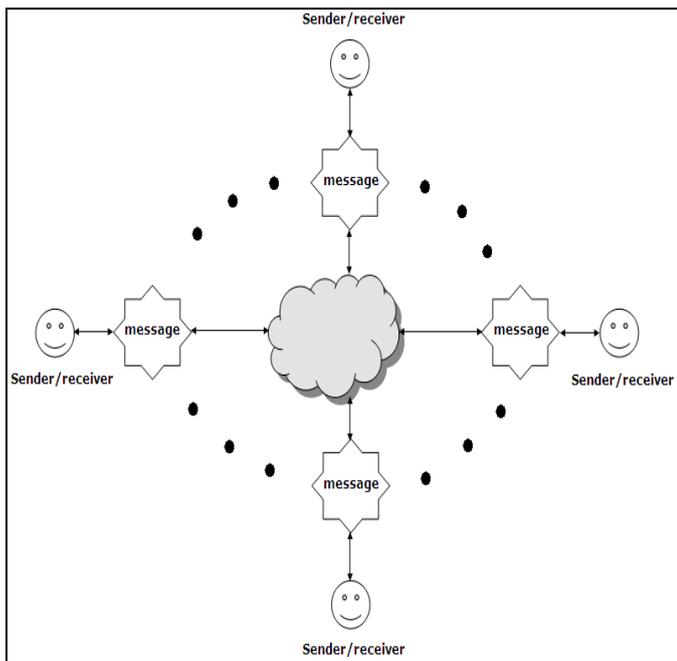


Figure 6: A communication model

The sending and receiving message contains the same representation of awareness. In the figure of communication model, the star shapes with eight vertices symbolize the existence of eight awareness types along with the message.

Comparison has been made on how and to what extend four digital elements, namely text, 2D graphic, 3D avatar and audio-video support the above-mentioned eight awareness types. The result is depicted in Table 1.

Table 1: Awareness and their representation in various media

Awareness	Text	2D Graphical	3D Avatar	Audio - Video
<i>Awareness of presence</i>	text	graphic	graphic	in person
<i>Awareness of state</i>	text	graphic	graphic	in person
<i>Awareness of role</i>	hidden	object's appearance	object's appearance	hidden
<i>Awareness of turn taking</i>	no	yes	no	no
<i>Awareness of emotions</i>	explicitly express	explicitly express	explicitly express	implicitly express
<i>Awareness of identities</i>	yes	yes	yes	no
<i>Contextual awareness</i>	no	yes	yes	no
<i>Conversational awareness</i>	lengthy communication	simplify communication	simplify communication	lengthy communication

Awareness of presence is the indication of how a user knows who is in the virtual space, how many participants are involved, where they come from and are they available [6]. It is uniquely presented by each of the four digital elements. Text base systems present the awareness in a form of list. The list displays users' identification (id), name, nickname or message as user login into the virtual space [2] as shown in Figure 7.



Figure 7: An example of a buddy list from facebook [2]

When a user logs out from the virtual room, the user's id will be removed. Referring to Figure 7, colors

and shapes indicates whether they are currently chatting or logged-in but not currently chatting. Once a user logged into the virtual space, the same id will be available to everyone in the workspace, even though the user prefers to use different identification to be displayed to different users [1]. In some cases, a user can select the visibility status to a specific group of users.

Unlike text, both 2D and 3D avatar present users in a simpler graphical image which can be as simple as a small dot [6] with different shape, size and color. Usually, they are displayed on a floor map, which can be in a form of geographical map, hierarchy tree, organization chart, radar or a room as the background. Some of these objects can perform limited animations such as jumping, smiling and changing colors [10].

On the other hand, 3D avatar (embodiment of human) presents user in a more realistic way. It can imitate and perform most of the human actions like walking, sitting, dancing, running and facial expressions. The avatar can walk into a room or walk out of a room as users logged-in or logged-out of a virtual room. Most of the systems allow users to select and groom their avatars to the best illustration of themselves. In a formal collaboration, the avatar's appearance remains the same until the end of a project. This rule is applied to avoid confusion among collaborators because a slight change of appearance can arouse discomfort among players. Unlike other media, audio-video presents user as a real person where the user's face appears on the screen. The awareness of presence is achieved by displaying the collaborators' faces on the windows. In conclusion, different digital elements have different ways of supporting the awareness of presence.

Awareness of state is a situation whereby a user's immediate state of mind is visible to other collaborators. The state can be best represented by using audio-video digital element due to the synchronization between users' actions and their state of minds. For example, yawning, mood swing, anger or non-attentive actions are automatically visible to others via a video. The video can implicitly express the awareness of state without any control on the users' sides.

Unlike audio-video, text media only allows users to explicitly express their states by selecting the built-in phrases such as "I am busy", "I am not in front of my computer" and "Online but not available" [1,8]. These phrases usually appear besides the users' names in the login lists. Sometimes the users' identifications are dimmed to indicate they are not active in the on-line communication. Like text, 2D and avatar allow users to decide their own states by using graphical images. For instance, static or dimmed color of icons is used in a 2D system [6] to indicate that users are unavailable or

inactive. Since avatar can perform most of the human actions, the state of an avatar can easily be identified by simply looking at it. For example, an avatar can walk out of a virtual space to indicate that the user is leaving the workspace and in a game environment, an injured avatar will not be able to stand or walk due to injury. It is also possible to have an avatar stares at an empty space to indicate the inactive user.

Awareness of role is referred to as user's position in the virtual space during collaboration like supervisor, administrator, visitor, student, tutor, king or peasant. It is best supported by avatar as compared to others due to its ability to illustrate the scenario. The avatar that represents a project leader will be wearing a project leader's name tag, chairing a meeting and holding a laser pointer. In a virtual game, the outfits such as costumes, weapons, size and facial expressions indicate different status of the avatars [26]. A leader is normally exhibited as taller, more handsome and holding a much more outstanding weapon. In short, the recognition of the users' status can be extracted from their avatars' appearance.

Although 2D graphics support awareness of role in a form of objects, its representation is very much limited and less realistic as compared to avatar. Different shapes and colors are used to indicate the role played by users. Usually there is a reference table that associates the different shapes and colors with the played roles. Thus, the users' role is quite transparent in a 2D system. In contrast, text and audio-video systems display users' profiles only when requested. They are hidden and could not be identified just by glancing at the users' identifications. Therefore, in order to know details about users' roles, the tooltip or drop-down menu can be used.

Awareness of turn-taking is when users are aware of who is talking, who is listening, whose ideas it is and whose turn to talk. Studies have shown that certain characteristics of users can monopolize the turn in the collaboration. For example, in socializing situation, talkative users get more turn to express their opinions even though their ideas are less quality as compared to others [19]. This leads to a bias outcome, favoring only to a certain group of people. Thus, managing turn taking in collaboration is important issues [27] so that all users have equal rights to express their opinions.

Among the digital elements, only 2D graphical objects are able to support the awareness of turn taking transparently. For example, numbers and objects position on a floor map are used to represent the turn taking. In addition, a simple animation like jumping can indicate the user's turn. However, in text mode system, everyone can communicate at the same time with many topics that lead to floor control conflict. Nevertheless, typing cue appears when a small number of users are typing their texts during the interaction. In the large

number of users, the typing cue element is not offered [1] due to the complexity in managing multiple users. Similarly, systems that use avatar fail to provide turn-taking awareness [4]. There is no turn-taking indicator that can control turn-taking. Therefore, the turn taking control is user dependent and the active user can freely use such opportunity to convey information in the virtual space. For the audio-video system, the turn-taking awareness is not provided. Users rely on sound rather than visual in order to know who are interacting with them so they have no idea who is viewing them [1].

Besides awareness of turn-taking, awareness of emotion is no doubt affecting the process and conversation outcome. In audio-video environment, awareness of emotion is supported implicitly from communication cues such as gesture, eye contact and tone of voice. In contrast, text, 2D graphics and 3D avatar support the awareness explicitly where users decide on the feelings such as "I am sad", "I am happy" and "I am not in a mood". Furthermore, misinterpreting of feelings and meanings occur in a text mode system due to the use of short forms. Proper words are important in communication to avoid misinterpretation and upset other people's feelings. One example of politely rejecting others is to say, "I understand your point of view but from the chart, it is costly to go for Plan B. Therefore, I believe we should reject Plan B". However, in an on-line interaction, the same statement is simplified as "Reject B be' costly". It sounds harsh and rude, thus, it affects the flow and mood of the communication.

Instead of words, awareness of emotions are represented by cute and funny emoticons in 2D system [1]. Most of these emoticons are predefined and uncustomized. Like text, users have to decide which emoticons will represent their emotions. However, they can fake their true emotions during interaction. The 3D avatar supports limited facial expression and body movement to express emotion awareness [2,8]. Figure 8 shows some of avatar emotions.

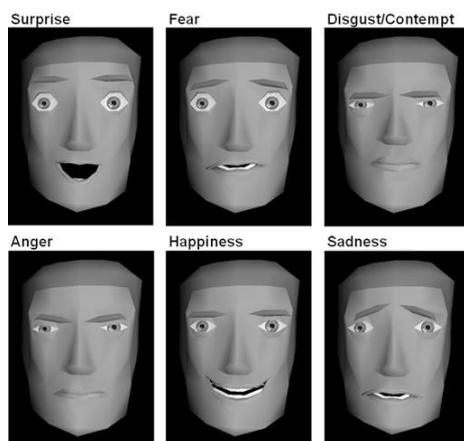


Figure 8: Some of emotions expressed by avatar [20].

Similar to text and 2D-graphical media, users have to initiate the emotion to be expressed. Therefore, the true feelings and emotions of users could be doubted [8]. Figure 9 shows a window and a list of emotions to be selected.

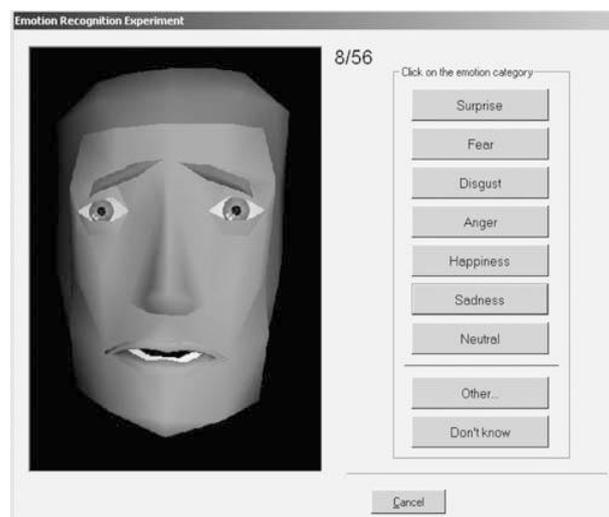


Figure 9: A window for emotion selection [20].

The awareness of identity is when users have choices to use different identity in different virtual space [1]. For example, among closely related people, their identifications resemble who they really are in person. The awareness is well supported by text, 2D graphics and 3D avatar but not in audio-video system. 3D avatar offers easier identification and roles. For example, the avatars' costumes and performances can reveal the role they play in a game, as a king, a soldier or a wizard [3].

Another awareness that is equally important is contextual awareness where users in a virtual space are aware about the task and progress of themselves as well as others [1]. Contextual awareness is well-supported by 2D graphics and 3D avatar. For example, in tracking the progress of a project, the 2D media offers the use of digital elements such as progression chart, graph and other 2D objects. Graphs can also present individual contribution and progression. In gaming environment, the 3D avatar supports contextual awareness such as showing the level of gas on the car meter, showing the points for each level of achievements and indicating the level of authority by using injured avatars [3].

Lastly, conversational awareness means knowing what users are talking about and what they are referring to. Such type of awareness is poorly supported by the text and audio-video digital elements where lengthy words are used in the communication. For example, the words "The left lower part of the green object should be moved to the lowest middle of the biggest object" could be simplified by pointing to the object and say, "Move this to there". However, 2D graphics and 3D avatar

systems allow users to use flashing arrows to point directly to objects and artifacts under discussion [3, 10]. Thus, such digital elements can increase conversational awareness and simplify communication.

In conclusion, the digital elements are independent from each other. Each element supports awareness differently in its own ways. In other words, one media cannot support all awareness types. For effective communication, digital elements must be combined to successfully support awareness in enhancing virtual communication.

3.2. Digital Elements vs. Applications

A study has been performed on the selected digital elements; text, 2D, avatar, none-verbal audio, verbal audio (pre-defined), voice communication and audio-video, to review their applications in collaborative applications. The applications include games, e-learning, collaborative works like project management, e-meeting and resources sharing. Text uses word as a mean of communication to express idea or message from sender to receiver, whereas 2D objects use any graphical image as a mean of conveying non-verbal message. Similarly, 3D object via avatar is used to communicate non-verbally. Users can act by using non-verbal audio to produce sound effect in a game. The examples are the sound of an explosion, cracking sound from a door or a sound of a car engines. The sounds are stored in the system's library along with pre-defined verbal-audio communications like "Hello", "Bye-bye" and "How are you?". Users retrieve the pre-defined items by explicitly from the menu selections in the system. In contrast, voice communication is supported by devices such as speaker and microphone for verbal communication. Users use audio-video device such as camera for exchanging message. Five games, four e-learning systems and six collaborative works have been analyzed to reveal the use of digital elements in such applications.

Table 2: Digital elements in collaborative games

Type	Star Wars Galaxie [8]	Battlefield 1942 [3]	World of Warcraft [32]	Second Life [32]	There [32,33]
Text	✓	✓	✓	✓	✓
2D	x	x	x	x	x
Avatar (gesture)	✓	✓	✓	✓	✓
None-Verbal Audio	✓	✓	✓	✓	✓
Verbal Audio (pre-defined)	✓	✓	✓	✓	✓
Voice Communication	-na-	x	x	✓	x
Audio-Video	x	x	x	x	x

In collaborative games, text is used by all the games

as the communication tool. Text may appear in a form of chatting log or bubble text. In addition, 3D avatar, non-verbal audio and verbal audio must be used in all games to support realistic environment and to boost up the excitement during the play. Surprisingly, audio-video is not used in any of these games. The reason is probably due to the high bandwidth requirement for smooth data transmission.

Collaborative learning has increased its popularity. From Table 3, text is still the best type of communication tool for e-learning although some systems do make use of other elements.

Table 3: Digital elements in collaborative learning

Type	Buddy space [6]	Viras [2]	Croquet [5]	CLEV-R [12]
Text	✓	✓	✓	✓
2D	✓	-na-	-na-	x
Avatar (gesture)	x	✓	-na-	✓
None-Verbal Audio	✓	-na-	✓	-na-
Verbal Audio (pre-defined)	x	-na-	-na-	-na-
Voice Communication	x	-na-	✓	✓
Audio-Video	x	-na-	✓	✓

In collaborative works, text and 2D graphics are widely used. Table 4 shows the use of digital elements in the collaborative works.

Table 4: Digital elements in collaborative work

Type	SLMeeting [28]	Activity-Explorer [29]	Multi-VNC [29]	TikiWiki 1.7 [30]	DIAMS [31]	Walkabout (IM) [29]
Text	✓	✓	✓	✓	✓	✓
2D	x	-na-	✓	✓	✓	✓
Avatar (gesture)	✓	x	x	x	x	x
None-Verbal Audio	✓	x	x	x	x	x
Verbal Audio (pre-defined)	-na-	x	x	x	x	x
Voice Communication	✓	x	x	x	x	x
Audio-Video	x	x	x	x	x	x

Unlike other systems, 2D graphics play important role in collaborative works. This digital element is being used to support awareness and to keep track of user activities and actions during collaborative activities via activity trackers such as graph, map, radar and chart. The activity trackers offer the ease of monitoring during

the collaborative work. Other digital elements are hardly used in monitoring the work progresses.

Viewing from different perspective, even though text and voice are categorized under verbal communication, it is obvious that text is more favorable than voice communication. It exists in all collaborative systems under studied. Similar to voice, 2D graphics are also unfavorable when it comes to NCVE applications. However, it exists in distance learning and e-meetings. On the other hand, avatar and non-verbal audio (sound effect) are used in most applications except in collaborative work. Avatar and audio are widely used in game to create realistic environment and to boost excitement during the play. No other application makes use of it. However, the verbal communication is preferred in a more formal environment like e-learning and e-meeting. Similarly, audio-video is favorable in a formal collaborative environment and can be found in e-learning systems.

In conclusion, text is still the most favorable type of digital element used in collaborative communication even though other media has more sophisticated and realistic illustrations.

4 Conclusion

Awareness is crucial in ensuring successful communication in virtual space. Unlike face-to-face communication, virtual communication lacks of communication cues such as gesture, eye contact, facial expression and body language.

In the first part, we identify eight types of awareness models: awareness of presence, awareness of turn taking, awareness of emotion, awareness of identities, contextual awareness, conversational awareness, awareness of state and awareness of role. Based on the awareness models, we compare four different digital elements namely text, 2D graphic, 3D avatar and audio-video and discuss to what extent they support awareness. Our findings show that the digital elements cannot stand alone on its own as a mean of communication since each has its own strengths and weaknesses. Creative combinations of various digital elements will be able to promote effective communication.

In the second part, the review shows that text is the most favorable element for communication ranging from personal chatting up to a more serious type of communication. Unexpectedly, audio communication and audio-video fall behind in terms of their usage. This might be due to the higher bandwidth required by these digital elements and the quality of data transmission by the media needed in real-life expectation. In the future, we will model the above-mentioned digital elements to be embedded in collaborative systems.

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