Published in final edited form as:

West J Nurs Res. 2014 October ; 36(9): 1222–1237. doi:10.1177/0193945913518993.

A Theoretical Framework for a Virtual Diabetes Self-Management Community Intervention

Allison Vorderstrasse¹, Ryan J. Shaw¹, Jim Blascovich², and Constance M. Johnson¹

¹Duke University School of Nursing, Durham, NC, USA

²University of California, Santa Barbara, USA

Abstract

Due to its high prevalence, chronic nature, potential complications, and self-management challenges for patients, diabetes presents significant health education and support issues. We developed and pilot-tested a virtual community for adults with type 2 diabetes to promote self-management education and provide social support. Although digital-based programs such as virtual environments can address significant barriers to reaching patients (i.e., child care, transportation, location), they must be strongly grounded in a theoretical basis to be well-developed and effective. In this article, we discuss how we synthesized behavioral and virtual environment theoretical frameworks to guide the development of SLIDES (Second Life Impacts Diabetes Education and Support).

Keywords

diabetes self-management education; type 2 diabetes; virtual environment; theoretical framework

With expanding availability of internet access, more immersive virtual environments (i.e., computer-generated 3D representations of an environment that promote users' perceptions of actual presence in the environment; Gorini, Gaggioli, Vigna, & Riva, 2008) are a potential solution to the logistical problems of providing diabetes self-management training and support (DSMT/S) to increasing numbers of patients with type 2 diabetes (T2D). Simply implementing existing DSMT/S curricula or interventions within virtual environments, however, is not sufficient to affect health outcomes and care delivery.

To address the challenges and opportunities virtual environments provide over face-to-face environments, theoretical frameworks and constructs from virtual environments integrated with behavioral theories are needed to effectively make this transition. Behavioral interventions for DSMT/S have traditionally and appropriately been guided by behavioral theories, such as social cognitive theory (SCT; Norris, Engelgau, & Narayan, 2001; Norris et

© The Author(s) 2014

Reprints and permissions: sagepub.com/journalsPermissions.nav

Corresponding Author: Allison Vorderstrasse, Duke University School of Nursing, 307 Trent Dr., DUMC 3322, Durham, NC 27710, USA. allison.vorderstrasse@duke.edu.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

al., 2002). The SCT (Bandura, 2001) provides a framework for addressing interactive or reciprocal factors in relation to DSMT/S including environmental, personal, and behavioral components. Integrating SCT with virtual environment theoretical constructs capitalizes on the strengths of successful self-management interventions (e.g., the incorporation of SCT with frequent patient-provider interactions, peer support, feedback, and a multidisciplinary team) and enhances the intervention and participants' experiences by overcoming the many weaknesses of current intervention techniques (e.g., a lack of interactivity, accessibility, and sustainability; resource intensiveness). In this article, we describe the synthesis and operationalization of behavioral and virtual environment theoretical constructs to build a virtual environment for adults with T2D called SLIDES (Second Life Impacts Diabetes Education and Support) that provides DSMT/S for participants in a virtual community.

Theory Development

The overarching goal of the SLIDES intervention was to build a realistic appearing virtual community for DSMT/S that would promote social support and transfer of behaviors learned in the virtual environment community to the physical world. Briefly, SLIDES is a virtual environment community that was constructed as a town with typical buildings such as a grocery store, restaurant, gym, bookstore, community center, and more (Johnson et al., 2013). Participants with T2D could enter this virtual environment through the Second Life Viewer over the Internet 24/7. Once the participants entered the site, they appeared as an avatar (that was created through their individualized preferences) in the SLIDES community. They were then free to visit any one of the locations in the site such as the grocery store, gym, restaurant, or others, and review the resources, interact with the objects such as gym equipment or grocery store items (by clicking on them to bring up nutrition information and feedback, having their avatar walk/run or exercise on the gym equipment, or mimic exercise videos in front of their computer), watch videos, review previous classes, or attend weekly DSMT/S classes synchronously with diabetes educators and other participants with diabetes. Any time the participants entered the site, they could interact via synchronous voice communication with other participants with diabetes who were in the site at the time. In essence, it was a social networking site that contained significant information and feedback embedded in virtual places such as grocery store food items, restaurant menus, pharmacy items, and other related resources. In developing this community, we were guided by a theoretical framework in which we combined SCT and constructs from virtual environment theoretical frameworks. We integrated these theories to support moving DSMT/S into a virtual environment in a theoretically grounded manner.

SCT (Figure 1) provided the theoretical basis for the DSMT/S intervention(s) utilized in the SLIDES virtual community. SCT posits that people acquire knowledge, skills, and new behaviors by not only doing but also observing others in the context of their environment, social interactions, and experiences (Bandura, 1989, 2001). SCT emphasizes the importance of cues to action, self-efficacy, and skill development in producing health behavior change (Bandura, 1977, 1989, 1997, 2001; Bandura & Wood, 1989). Primary and reciprocal components of SCT include the environment, personal factors, and behavior. In the context of DSMT/S, these components influence human behavior and behavior change and ultimately, metabolic control. This theory has been the basis of many successful diabetes

self-management interventions (Glasgow et al., 2006; Melkus et al., 2004; Miller, Edwards, Kissling, & Sanville, 2002).

In developing SLIDES, we considered the three main components of SCT (i.e., environment, personal factors, and behavior) in combination with the attributes and theoretical constructs of virtual environments (Figure 2). Here, we discuss the integration of virtual environment theory constructs and social support with each of the three primary components of SCT.

Environmental Factors

According to SCT, there are many important aspects of the environment to consider in DSMT/S interventions. These aspects include the community, resources, and support surrounding the person. Typically, the “environment” in which DSMT/S occurs is the physical clinic or classroom in which participants meet with educators and health professionals for scheduled classes and curricula. Yet, we know that this type of DSMT/S leaves a disconnection between participants’ real worlds or daily lives and the classroom (Funnell & Anderson, 2002, 2003a). In recent years, this gap has been addressed by attempting to bring DSMT/S participants to the locations critical to their self-management such as grocery stores (Brown, Garcia, Kouzekanani, & Hanis, 2002). However, such relocation presents barriers of its own related to transportation, costs, time, and scheduling issues. We addressed this disconnect in an innovative manner by building a virtual community, SLIDES, that would mimic a physical-world town to provide access to education in a virtual classroom as well as to promote knowledge application in community locations involved in daily self-management (i.e., grocery store).

Important virtual environment constructs that are environmental factors include physical realism, behavioral realism (including social interaction through synchronous communication), and usability (see Table 1 for definitions). To promote knowledge application, the construction of the virtual environment was modeled after a town or “Main Street” to convey a sense of physical realism that we hypothesized would translate into behavioral realism. We included applicable resources in each community location that were primarily informational (i.e., nutrition information and suggestions for preparation or substitutions in the grocery store). Given that the “community” was intended for those with diabetes, this allowed for information seeking in a safe, supportive, and reliable environment. Participants knew that the research team was there to facilitate their learning and support them, as were their peers with diabetes. We hypothesized that these resources would influence personal factors (psychosocial outcomes) as well as behavior (self-management) as noted in the reciprocal nature of SCT.

This sound theoretical underpinning would not have been sufficient unless we could address the attributes or constructs related to virtual environments that are essential to their usability. These include the fidelity of structures and the ease of use of the avatars, voice or text communication, and virtual community.

Personal Factors

Personal factors that need to be promoted in virtual environments include participant perceptions of presence, co-presence, agency, and social influence, which should work within this setting to enhance diabetes knowledge, self-efficacy, and perceived support. To establish support within the virtual community and influence transfer of learning to the physical world, participants needed to be immersed or feel a sense of “presence” in the community. Individuals who are more immersed have a greater sense of presence when interacting with either embodied agents or avatars (Blascovich et al., 2002; Slater, Sadagic, Usoh, & Schroeder, 2000). Presence is defined as the subjective feeling of being in a particular place even though the user is physically situated in another environment. Co-presence is the perception of being in the environment with others (Schroeder, 2002). In relation to virtual environments, the user feels as though they are really present in the virtual environment or have the feeling of “being there” (Blascovich et al., 2002; Slater et al., 2000; Witmer & Singer, 1998), even though they may be physically at home at their desks.

Co-presence is also a function of agency (whether people see other avatars as representations of real people; Schroeder, 2002) and behavioral realism (extent that objects or avatars behave as they would in the real world). According to Blascovich’s Threshold Model of Social Influence, when agency and/or behavioral realism increase, presence should increase (Blascovich et al., 2002). To experience presence, two different psychological states are required: involvement, which is focused attention and immersion or feeling “enveloped by” the environment through a continuous stream of experiences and stimuli (Witmer & Singer, 1998). Increased presence has been linked to the following: (a) knowledge transfer (transferring knowledge gained in a virtual world to the real world; Slater, Linakis, Usoh, & Kooper, 1996); (b) the potential for better learning and performance (Witmer & Singer, 1998); and (c) behavior consistent with that of the real world (Slater, Usoh, & Chrysanthou, 1995). Research has shown that social processes that occur in real life also occur in virtual environments (Hoyt, Blascovich, & Swinth, 2003). Therefore, the construction of the virtual community as a “town” was intended to provide opportunities for social processes and social interaction.

Social influence is a compelling way to learn through both immediate feedback from instructor to student, or peer to peer, as well as through models that learners can mimic (Okita, Bailenson, & Schwartz, 2008). In an experiment to determine whether better learning occurs through avatars (controlled by a human) or through bots (computer simulated, scripted avatars), Okita et al. (2008) found that people learned better with an avatar because of the belief of the participants that they were interacting with another human. In SLIDES, avatars (other participants) as well as bots were part of the virtual community.

Various aspects of the SLIDES community were created to support participants’ knowledge, self-efficacy, and perceived support. Diabetes knowledge was addressed in the DSMT/S classes with diabetes educators, conducted synchronously on a weekly basis using evidence-based curricula from the American Association of Diabetes Educators (AADE, 2008).

Self-efficacy (outcomes expectations) was promoted by the interactions with health professionals and participants within the SLIDES community. Participants worked with educators to gain knowledge, set goals for self-management, and practice these behaviors in a non-threatening virtual environment. Practicing behaviors in a virtual environment allows participants to receive feedback (programmed or from other people in the environment) where they have the freedom to make mistakes and learn from them without the consequences of “real-life” choices.

Another important aspect of successful diabetes self-management is social support (Funnell & Anderson, 2003a, 2003b; Glasgow, Strycker, Toobert, & Eakin, 2000). We incorporated multiple dimensions of support (i.e., informational, formal, informal) in our virtual community that participants could use and apply to self-management in their everyday lives. Traditional DSMT/S interventions do not allow for easily accessible, participant-directed, or ongoing support via regular group meetings or other means due to their cost and time-limited nature. Our virtual community, however, provides a means for participants to meet with each other in an ongoing manner at any time regardless of geographic location and allows access to the site 24/7.

Self-Management Modeling and Practice

Another key component of SCT is the application and knowledge transfer from DSMT/S to “real life.” The literature on virtual environments supports that such gained knowledge can be transferred to the “real world” (Okita et al., 2008; Slater et al., 1996). Patients with T2D manage 95% of their own care through DSMT/S (i.e., blood glucose monitoring, diet, physical activity, medication therapy, foot care, and coping; Funnell & Anderson, 2003a). We hypothesized that participants’ self-management behaviors would improve over the course of their immersion in SLIDES.

According to SCT, behavior modeling is an important aspect of learning and behavior change. The SLIDES intervention allowed for modeling of behaviors by health professionals, others with diabetes, as well as the bots. Participants interacted with others (health professionals, other participants) through their avatars to learn, imitate, and role-play healthy self-management behaviors in the SLIDES community. In our pilot testing of SLIDES, there were multiple opportunities for peers and instructors/professionals to model behaviors in the site, in areas such as the gym, restaurant, and grocery store. Peer learning has been associated with improved self-management behaviors and metabolic control in the literature to date (Gagliardino et al., 2013).

Theory Operationalization

All constructs are defined and their operationalization is summarized in Table 1. The environmental factors were operationalized to provide a realistic 3D community. Participants could enter the online community at any time and interact with other participants via voice or text chat to synchronously discuss living with and managing their diabetes or use resources within the community to learn more about their diabetes management (e.g., books, videos, nutrition information). Scripted bots (computer simulated, scripted avatars) provided help to users of the virtual community’s resources via scripted

feedback. Scripted feedback was provided when participants selected various objects in the site. For example, if a participant selected a pie in the grocery store, he or she was given feedback on serving size, substitutions, and nutritional information.

To ensure that technical issues would not discourage participants from using the virtual environment, we paid attention to usability of the SLIDES community. We worked with the programmers to place the virtual community within a user-friendly viewer that included only the basic and necessary functions (e.g., walking, talking, changing clothes, point and click access to resources) so that the participants would not feel too overwhelmed by technological features.

Agency was enhanced in SLIDES by allowing participants to create avatars through which they represent their own physical appearance; and through the use of gestures and voice conversations with other participants via their avatars. In addition to body size, shape, hair color, and other characteristics, participants could change their avatar's clothing, which added to the realism and sense of agency as well.

SLIDES also provided accessible synchronous diabetes education in the context of "everyday" life regardless of participants' geographic location. Although synchronous DSMT/S classes took place in a classroom in the virtual community (Figure 3), the educators and participants were able to use the dynamic digital environment, such as the grocery store (Figure 4), bookstore, and gym, during classes to facilitate real-time application of learning and behaviors directly and immediately. For example, during one class, participants went to the restaurant to eat together, discuss choices that mimic real restaurant options, and received programmed and peer/professional feedback regarding their menu selections. In another example, diabetes educators took the group of participants attending a weekly DSMT/S class to the grocery store to look at nutrition information and decided how to choose the best options. This type of applied learning has been associated with behavior change and improved self-efficacy (Naik, Teal, Rodriguez, & Haidet, 2011). Behavioral practice and modeling in this environment allows for exploration and mistakes (i.e., selection of unhealthy foods) without the consequences of actually having purchased and consumed them.

Additional features supported knowledge gain including informational resources in the bookstore (e.g., links to books, websites, patient literature), pharmacy (e.g., links to products and product information, medication references), and feedback regarding selections in the grocery store and restaurant. Knowledge was also enhanced by the ability of participants to learn from one another and their experiences with T2D. Support sessions were held synchronously in addition to the scheduled DSMT/S classes and monitored by a study team member to ensure accuracy of information discussed by participants. Peer-to-peer information sharing also occurred using an embedded forum in the community center, which allowed for asynchronous sharing and support.

Social support was enhanced by social interaction, resources, and peer support within SLIDES. SLIDES allowed participants to have synchronous conversations and interactions

with each other or the study team using voice or text communication; as discussed above, it also bestows the sense of social presence, or “being there with others” via avatars.

In addition to interaction with educators and peers in the DSMT/S classes, the physical environment also facilitated social interaction. For example, the community center, restaurant, and outdoor seating areas promoted social interaction among participants by providing meeting venues and seating areas. These were accessible opportunities to meet and interact virtually with others, without having to find the medium for those interactions or travel outside the home. Social influence was enhanced by the realism of the environment and the behavioral realism of the avatars, which then enhanced agency as discussed above.

Discussion

Our virtual environment community known as SLIDES was developed based on behavioral theories and virtual environment constructs, current evidence regarding effective self-management interventions, previous research in virtual environments, and professional guidelines. The backgrounds and expertise of our research team members with regard to these various areas of study were critical to the successful development of the site, including virtual environments, informatics, behavioral research, diabetes intervention research, diabetes clinical expertise, and diabetes education. This program used the capacity of the virtual environment platform to provide synchronous interactions with health care providers and other adults with diabetes, and scenarios and simulations for skill building that can be transferred to real-life diabetes self-management behaviors. Although the virtual delivery of health care interventions and education is moving forward rapidly, it is important to ensure that interventions are developed with a strong theoretical basis such as the framework described here for SLIDES.

Based on research supporting the effectiveness of self-management in improving clinical outcomes (HbA1C, blood pressure), we hypothesized that participant metabolic control would improve over time. Preliminary outcomes from our pilot study sample are forthcoming, and the efficacy of this intervention will be further evaluated in ongoing larger trials statistically powered to establish effectiveness. Measuring the intermediate outcomes or constructs in this framework such as self-efficacy, perceived support, and knowledge, and virtual environment constructs such as presence and co-presence, will allow for testing of this model in larger studies. This will provide evidence as to the fit of the framework in a virtual environment chronic disease intervention and the relationship of the environmental, personal, and behavioral factors among participants.

This theoretical framework has implications beyond our intervention research in diabetes self-management. On a broader clinical and research scale, the framework could be applied to developing virtual platform interventions for other chronic diseases. With additional policy, health care systems, and legal implications (privacy, licensure) considered, this framework could be utilized for virtual interventions that include provider clinical disease management with patients. Much of the ongoing chronic disease management that occurs in clinical practice would benefit from the remote accessibility, and even group visits could be facilitated in this type of environment. Research that applies this framework to virtual

interventions for chronic disease management or prevention would establish the wider applicability and validity of this theoretical framework as well.

Acknowledgments

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study was funded by the National Library of Medicine (1R21LM010727-01).

References

- American Association of Diabetes Educators. AADE 7 self-care behaviors. *Diabetes Educator*. 2008; 34:445–449. [PubMed: 18535317]
- Bandura A. Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*. 1977; 84:191–215. [PubMed: 847061]
- Bandura A. Human agency in social cognitive theory. *American Psychologist*. 1989; 44:1175–1184. [PubMed: 2782727]
- Bandura A. The anatomy of stages of change. *American Journal of Health Promotion*. 1997; 12:8–10. [PubMed: 10170438]
- Bandura A. Social cognitive theory: An agentic perspective. *Annual Review of Psychology*. 2001; 52:1–26.
- Bandura A, Wood R. Effect of perceived controllability and performance standards on self-regulation of complex decision making. *Journal of Personality and Social Psychology*. 1989; 56:805–814. [PubMed: 2724068]
- Blascovich J, Loomis J, Beal A, Swinith K, Hoyt C, Bailenson JN. Immersive virtual environments technology as a methodological tool for social psychology. *Psychological Inquiry*. 2002; 13:103–124.
- Brown SA, Garcia AA, Kouzekanani K, Hanis CL. Culturally competent diabetes self-management education for Mexican Americans: The Starr County border health initiative. *Diabetes Care*. 2002; 25:259–268. [PubMed: 11815493]
- Funnell MM, Anderson RM. Working toward the next generation of diabetes self-management education. *American Journal of Preventive Medicine*. 2002; 22(Suppl 4):3–5. [PubMed: 11985929]
- Funnell MM, Anderson RM. Changing office practice and health care systems to facilitate diabetes self-management. *Current Diabetes Reports*. 2003a; 3:127–133. [PubMed: 12728638]
- Funnell MM, Anderson RM. Patient empowerment: A look back, a look ahead. *Diabetes Educator*. 2003b; 29:454–458. 460, 462. [PubMed: 12854337]
- Gagliardino JJ, Arrechea V, Assad D, Gagliardino GG, Gonzalez L, Lucero S, Clark C Jr. Type 2 diabetes patients educated by other patients perform at least as well as patients trained by professionals. *Diabetes/Metabolism Research and Reviews*. 2013; 29:152–160. [PubMed: 23166062]
- Glasgow R, Nutting P, Toobert D, King D, Strycker L, Jex M, Merenich J. Effects of a brief computer-assisted diabetes self-management intervention on dietary, biological and quality-of-life outcomes. *Chronic Illness*. 2006; 2:27–38. [PubMed: 17175680]
- Glasgow R, Strycker L, Toobert D, Eakin E. A social-ecologic approach to assessing support for disease self-management: The Chronic Illness Resources Survey. *Journal of Behavioral Medicine*. 2000; 23:559–583. [PubMed: 11199088]
- Gorini A, Gaggioli A, Vigna C, Riva G. A second life for eHealth: Prospects for the use of 3-D virtual worlds in clinical psychology. *Journal of Medical Internet Research*. 2008; 10:e21. [PubMed: 18678557]
- Hoyt C, Blascovich J, Swinith K. Social inhibition in immersive virtual environments. *Presence*. 2003; 12:183–195.

- Johnson C, Feenan K, Setliff G, Pereira K, Shaw R, Hassell N, Vorderstrasse A. Building a virtual environment for diabetes self-management education and support. *International Journal of Virtual Communities and Social Networking*. 2013; 5(3)
- Melkus GD, Spollett G, Jefferson V, Chyun D, Tuohy B, Robinson T, Kaisen A. A culturally competent intervention of education and care for black women with type 2 diabetes. *Applied Nursing Research*. 2004; 17:10–20. [PubMed: 14991551]
- Miller C, Edwards L, Kissling G, Sanville L. Evaluation of a theory-based nutrition intervention for older adults with diabetes mellitus. *Journal of the American Dietetic Association*. 2002; 102:1069–1081. [PubMed: 12171451]
- Naik AD, Teal CR, Rodriguez E, Haidet P. Knowing the ABCs: A comparative effectiveness study of two methods of diabetes education. *Patient Education and Counseling*. 2011; 85:383–389. [PubMed: 21300516]
- Nielsen, J. Usability engineering. Boston, MA: Academic Press; 1993.
- Norris SL, Engelgau MM, Narayan KM. Effectiveness of self-management training in type 2 diabetes: A systematic review of randomized controlled trials. *Diabetes Care*. 2001; 24:561–587. [PubMed: 11289485]
- Norris SL, Nichols PJ, Caspersen CJ, Glasgow RE, Engelgau MM, Jack L, McCulloch D. The effectiveness of disease and case management for people with diabetes. A systematic review. *American Journal of Preventive Medicine*. 2002; 22(Suppl 4):15–38. [PubMed: 11985933]
- Okita S, Bailenson J, Schwartz D. The mere belief in social interaction improves learning. *International Conference for the Learning Sciences '08. Proceedings of the 8th international conference on International conference for the learning sciences*. 2008; 2:132–139.
- Schroeder, W., editor. *The social life of avatars*. London, England: Springer; 2002.
- Shneiderman, B.; Plaisant, C. *Designing the user interface: Strategies for effective human-computer interaction*. 5. Boston, MA: Addison-Wesley; 2010.
- Slater, M.; Linakis, V.; Usoh, M.; Kooper, R. Immersion, presence, and performance in virtual environments: An experiment with tri-dimensional chess. In: Green, M., editor. *Proceedings of the ACM symposium on virtual reality software and technology*. Hong Kong, Republic of China: ACM Press; 1996. p. 163-172.
- Slater M, Sadagic A, Usoh M, Schroeder R. Small-group behavior in a virtual and real environment: A comparative study. *Presence-Teleoperators and Virtual Environments*. 2000; 9:37–51.
- Slater, M.; Usoh, M.; Chrysanthou, Y. The influence of dynamic shadows on presence in immersive virtual environments. In: Goebel, M., editor. *Virtual environments '95*. Boston, MA: Springer Computer Science; 1995. p. 8-21.
- Witmer BG, Singer MJ. Measuring presence in virtual environments: A presence questionnaire. *Presence*. 1998; 7:225–240.

Figure 1.
Social cognitive theory.

Figure 2. Theoretical framework SLIDES intervention

Note. SLIDES = Second Life Impacts Diabetes Education and Support.

Figure 3. Classroom in SLIDES

Note. SLIDES = Second Life Impacts Diabetes Education and Support.

Figure 4.
Grocery store.

Table 1

Theoretical Constructs: Operationalization in the Virtual Environment.

Theoretical construct	Definition	Operationalized in virtual environment
Environmental factors		
Physical realism	Extent that objects appear and behave as they would in the real world (Schroeder, 2002)	Community and structures, resources, and objects modeled from physical environment to mimic "town"
Behavioral realism	Extent that objects or avatars behave as they would in the real world (Schroeder, 2002). Enhanced by social interaction via synchronous communication	Avatars were customized by participants and were able to talk, walk, run Information was embedded in objects as it would be accessed in the physical environment—that is, classroom, books, food products
Usability	Broadly defined as "ease of use," plus "usefulness," including such quantifiable characteristics as learnability, speed, and accuracy of user task performance, user error rate, and subjective user satisfaction (Nielsen, 1993; Shneiderman & Plaisant, 2010)	Fidelity of structures and avatars Ease of use of viewer platform used by participants to control the environment and their avatars
Resources	Materials, places, or people that provide informational, physical, or emotional support to patients in self-managing their diabetes	Books, websites, food, or grocery items, menus with actionable information in various site locations Diabetes self-management training classes and support group meetings Access to meeting with peers at will
Personal factors		
Presence	The subjective experience of being in one place or environment, even when one is physically situated in another (Blascovich et al., 2002)	Realistic structures, objects, environment and sounds that enhanced the perception of the environment being real
Co-presence	Perception of being in the environment with others (Schroeder, 2002)	Synchronous voice communication through avatars Avatars customized by participants Fairly realistic avatar movements and gestures
Agency	Whether people see other avatars as representations of real people (Blascovich et al., 2002)	Synchronous voice communication through avatars Avatars customized by participants Fairly realistic avatar movements and gestures
Social influence	Occurs when one's emotions, opinions, or behaviors are affected by others (Blascovich et al., 2002)	Synchronous peer and professional interaction to support sharing stories, information, experience, emotional support, and resources Result of agency, realism, and presence
Diabetes knowledge	Awareness and understanding of diabetes in terms of its definition, causes, symptoms, control, management, treatment, and complications	Enhanced by synchronous classes and support group meetings, resources and accessible information verified by diabetes educators (i.e., books, websites, nutrition information)
Self-efficacy	Patients' belief in their ability to perform health behaviors (i.e., healthy diet, physical activity, self blood glucose monitoring; Bandura, 1977)	Enhanced by ability to model and practice self-management behaviors in SLIDES before carrying them out in the physical environment Supported and encouraged by peers and professionals in SLIDES
Perceived support	Perception that people and resources are readily available and approachable by the patient to improve or enhance their ability to self-manage and cope with their diabetes	Enhanced by accessibility of peers and professionals who offered informational and emotional support for diabetes self-management
Self-management modeling and practice	Demonstration and role playing for learning and practicing of health behaviors	Environmental structure as realistic community settings and feedback (programmed or synchronous from peers or professionals) promoted practice and learning within SLIDES

Note. SLIDES = Second Life Impacts Diabetes Education and Support.