Older Adults, e-Health Literacy, and Collaborative Learning: An Experimental Study

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The theory-driven Electronic Health Information for Life-Long Learners via Collaborative Learning (eHILLL-CL) intervention, developed and tested in public libraries, aims to improve older adults’ e-health literacy. A total of 172 older adults participated in this study from August 2009 to June 2010. Significant differences were found from pretest to posttest in general computer/Web knowledge and skill gains and in e-health literacy (p < 0.001 in all cases; effect sizes: 0.5–2.1; statistical power: 1.00 even at the 0.01 level) and three attitude measures (p < 0.05) for both computer anxiety and attitudes toward the aging experience in physical change, and p < 0.01 for attitude toward the CL method; effect sizes: 0.2–0.3; statistical power: 0.4–0.8, at the 0.05 level). No significant difference was found in other variables. Participants were highly positive about the intervention and reported positive changes in health-related behavior and decision making. Group composition (based on gender, prior familiarity with peers, or prior computer experience) showed no significant impact on CL outcomes. These findings contribute to the CL and health literacy literatures and infer that CL can be a useful method for improving older adults’ e-health literacy when using the specific strategies developed for this study, which suggests that social interdependence theory can be generalized beyond the younger population and formal educational settings.

Introduction

Health literacy is “the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions” (U.S. Department of Health and Human Services, 2000). Coined in 1974 (Simonds, 1974), definitions of “health literacy” only began to emerge in 1999 (American Medical Association, 1999). This new field has attracted significant attention in recent years, particularly in response to a national survey (Kutner, Greenberg, Jin, & Paulsen, 2006) revealing a health “illiteracy” crisis in the United States. The study found only 12% of adults proficient in health literacy. Even more striking, only 3% of older adults demonstrated proficiency (Kutner et al., 2006).

The increasing use of information and communication technologies in healthcare (Oh, Rizo, Enkin, & Jadad, 2005) presents opportunities and challenges for improving health literacy. With an increasing amount of high-quality health information available online from government agencies and nonprofit and for-profit organizations, the Internet is already an important source for health information (Bylund, Sabee, Imes, & Sanford, 2007; Fox, 2011; Huntington, Nicholas, Jamali, & Russell, 2007). However, individuals who experience low health literacy rates typically also have low Internet literacy. Making use of online health information can be especially challenging for people lacking these skills, as frequently occurs with older adults (Fox, 2006; Kaiser Family Foundation, 2005; Xie, 2008d). These challenges demand interventions that promote older adults’ e-health literacy, which can be defined as “the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem” (Norman & Skinner, 2006b, p. e9).

This study aimed to advance scientific knowledge about the optimal learning methods for older adults, examining specifically whether and how collaborative learning (CL) might be a useful method in improving older adults’ e-health literacy in informal learning settings (e.g., public libraries). Building on and expanding the CL literature, along with the author’s prior research on older adults’ computer learning (Xie, 2005, 2006, 2007a, 2007b, 2007c, 2008a, 2008b, 2008c, 2010; Xie & Bugg, 2009; Xie & Jaeger, 2008), an e-health literacy intervention, Electronic Health Information for Life-Long Learners via Collaborative Learning (eHILLL-CL), was developed and tested. This article first addresses the CL theories, findings, and gaps, and then reports the experimental results of the eHILL-CL intervention.
CL: Theory and Gaps

CL, or “any instructional method in which students work together in small groups toward a common goal,” is one of the most common forms of active learning (Prince, 2004, p. 223). CL requires students to actively engage in the learning process by performing together meaningful activities and reflecting collaboratively on what they are learning (Bonwell & Eison, 1991).

The social interdependence theory supports the superiority of CL over individualistic learning (Johnson, Johnson, & Smith, 1998). Social interdependence theory originated from the work of psychologists such as Kurt Koffka, Kurt Lewin, and Morton Deutsch. The theory emphasizes the interdependence among group members by arguing that the group is a “dynamic whole.” Any change in the state of a group member changes the state of other group members. Building on Deutsch’s formulation that social interdependence among group members can be positive (collaboration), negative (competition), or nonexistent (individualistic efforts), Johnson, Johnson, and Smith (2007) argued that positive interdependence promotes positive interactions among group members and facilitates learning. Positive interdependence exists when individuals recognize that they can achieve their goals only when other group members achieve their goals (Johnson et al., 1998, 2007).

The effectiveness of CL is well documented: A meta-analysis of over 300 studies has provided powerful evidence that CL outperforms individualistic and competitive learning in postsecondary and professional settings (Johnson et al., 2007). Despite strong evidence showing an advantage for CL, major gaps in the literature exist and require further examination.

Gap 1: Generalizability

CL research within the social interdependence tradition is predominantly based on the formal education of younger adults (Johnson et al., 1998, 2007). Whether these findings can be generalized to older age groups in informal educational settings is unclear, given the considerable differences that exist between older and younger learners. Older learners are more experienced, more problem-oriented, and more likely than are their younger counterparts to feel self-responsible for learning. Further, older adults learn more effectively when they perceive the content of learning being relevant to their personal lives (Knowles, 1990). Older adults generally need more time to learn and perform better on outcome measures when learning is built upon existing knowledge base and complexity increases gradually (Belbin & Belbin, 1972; Glass, 1994; Hayslip & Kennelly, 1985; Sterns & Doverspike, 1987).

Research on older adults’ computer learning has shown that learning actively engaging learners (e.g., through hands-on practice, self-directed learning, or discovery-oriented/problem-solving exercise) is more effective than is conventional learning, which relies primarily on the instructor’s lecturing (Charness, Schumann, & Boritz, 1992; Cody, Dunn, Hoppin, & Wendt, 1999; Czaja & Drury, 1981; Gist, Rosen, & Schwoerer, 1988; Jay & Willis, 1992; Mayhorn, Stronge, McLaughlin, & Rogers, 2004). Note, however, that (a) active learning can take place in individualistic learning or CL environments (Prince, 2004), and (b) research on computer training for older adults has focused predominantly on individualistic learning, paying little attention to CL (The only known exception is Zandri & Charness, 1989, which provided evidence supporting the effectiveness of CL.) Further research is needed to establish a firm ground for the effects of CL among older computer learners.

Gap 2: Strategies

CL requires sophisticated and explicit strategies and instructions (Johnson et al., 2007; Kreijns, Kirschner, & Jochems, 2003). In formal educational settings, CL is promoted by relying heavily on assignments and grades as incentives for collaboration. Johnson et al. (1998, 2007) suggested five principles to promote collaboration: (a) Ensure that students understand that their scores depend on both individual and group members’ performance (e.g., by giving bonus points to each student if all group members score a certain percent or higher on a test); (b) structure individual accountability so that each student’s individual contribution is assessed (e.g., by giving individual tests, having each student explain his or her contribution to the group, or observing group interactions and documenting each student’s contributions); (c) ensure students help, assist, support, encourage, and praise each other’s learning efforts through face-to-face interactions; (d) ensure students have needed social skills (e.g., communication, leadership) and use them properly; and (e) ensure students have adequate time to engage in group interactions, reflect on effective strategies, and make decisions about what actions to continue or change.

While some of these principles and strategies may be applicable to older adults in informal educational settings, others are not. Recently, CL has begun to receive attention in the cognitive–developmental literature as a mechanism for improving cognitive abilities in older age (Elias & Wagster, 2007; Meegan & Berg, 2002; Strough & Margrett, 2002). While some (non-computer-related) studies have found positive impact of CL on older adults’ performance (Fried et al., 2004; Stine-Morrow, Parisi, Park, & Morrow, 2008), evidence also exists that CL has no impact, or even a negative impact, on older adults’ performance (Andersson & Ronnberg, 1995, 1996; Margrett & Willis, 2006). A major factor possibly contributing to the reported no or negative impact of CL is that existing collaborative cognition research generally does not provide detailed instructions that ensure collaboration (Margrett & Willis, 2006). Instead, participants are instructed to “work together” (e.g., Gould, Kurzman, & Dixon, 1994) or “collaborate as much as possible” (Andersson & Ronnberg, 1995) to complete a task. To ensure CL for older adults, it is critical to develop effective strategies that can produce results.
**Gap 3: Outcome Measures**

Outcome measures of existing CL research typically fall into one or more of the following broad categories: (a) knowledge and skill gains, (b) quality of interpersonal relationships (among students and between students and faculty), (c) psychological adjustment to college life (e.g., self-esteem, self-efficacy), and (d) attitudes toward the college experience (Johnson et al., 2007). These outcome measures also need modification when examining the effects of CL on older adults.

**Gap 4: Group Gender Composition and Group Composition Based on Familiarity With Partners**

Group composition affects group dynamics and may affect CL outcomes. Several studies have found more collaboration in groups with either a female- or a male-gender majority than in groups with equal gender composition (Busch, 1996; Maskit & Hertz-Lazarowitz, 1986) and in same-gender groups than in mixed ones (Maskit & Hertz-Lazarowitz, 1986; Underwood, McCaffrey, & Underwood, 1990). For group composition based on familiarity with partners, evidence exists that the time and effort spent on getting familiar with each other and coordinating performance may produce negative effects on the CL process and outcomes (Gould et al., 1994). This argument finds support in research that has reported CL with familiar partners as more effective than CL with unfamiliar partners in enhancing cognitive performance (Margrett & Marsiske, 2002) or in reducing the negative effects of collaboration (Andersson & Ronnberg, 1995, 1996). However, one study found that CL did not generate more benefits than did individualistic learning in older adults’ cognitive performance even with familiar partners such as spouses (Margrett & Willis, 2006). The impact of these two group-composition factors on CL requires further study, particularly because no known study has examined how these factors might influence CL in computer-related areas.

**Gap 5: Group Composition Based on Prior Computer Experience**

Prior computer experience is a strong predictor for older adults’ computer learning and performance (e.g., Charness, Kelley, Bosman, & Mottram, 2001; Czaja & Lee, 2001; Nair, Czaja, & Sharit, 2007). Cody et al. (1999), in their study of older learners, found that “the same [computer training] program was too challenging to some and insufficiently stimulating to others” (p. 282). Some researchers (e.g., Mayhorn et al., 2004) have suggested that to ensure the success of computer training for older adults, it is necessary to form homogeneous groups based on prior computer experience. This suggestion should be taken with caution given that to date, research on computer training for older adults has focused predominantly on individualistic learning while paying little attention to CL. While homogeneous groups based on prior computer experience might be more effective than heterogeneous groups in individualistic learning, this might not be the case for the CL condition.

In the general literature on CL, a lack of consensus exists about the relative effectiveness of different group compositions. Some researchers have argued that heterogeneous group composition is more effective than is homogeneous group composition in facilitating CL (Johnson & Johnson, 1999; Webb & Palincsar, 1996). Others have found mixed results where the relative strength of heterogeneous versus homogeneous group composition based on ability and experience appears to be dependent on the types of outcome measures (Campion, Medsker, & Higgs, 1993; Pearce & Ravlin, 1987). One study found no significant difference between the performance of groups comprised of members with similar levels of self-efficacy and those with mixed levels of self-efficacy (Wang & Lin, 2007). The impact of group composition based on prior computer experience requires further examination.

**This Study**

The present study is inspired by the author’s and other researchers’ research on older computer learners which has provided anecdotal (and initially unexpected) evidence that the social, collaborative process of learning (e.g., peer learning, friendship development) is an important component of older adults’ learning of computers (Billipp, 2001; Bradley & Poppen, 2003; Eilers, 1989; Karavidas, Lim, & Katsikas, 2005; White et al., 2002; Xie, 2007a, 2007c, 2008c; Xie & Jaeger, 2008). To systematically explore if, how, and why this process might affect older adults’ computer learning, CL, a learning method with a strong theoretical foundation supported by rich empirical data, was selected to serve as the framework for the present study. Realizing the gaps in the CL literature discussed earlier, the present study focused on exploring whether CL, when using the specific strategies developed for this study’s population (discussed later), can be a useful method for improving older adults’ e-health literacy, and what outcome measures (discussed later) might be more sensitive than are others in detecting the effects of CL among older learners.

Specifically, the following key research questions were examined:

**RQ1:** Are there differences in outcome measures before and after the intervention?

**RQ2:** What impact might the intervention have on older adults’ health-related behavior and decision making?

**RQ3:** What impact might group composition (gender; prior familiarity with peers; and prior computer experience) have on learning outcomes?

The following hypotheses were developed and tested in connection with RQ1:

**H1:** General computer/Internet knowledge increases significantly from pre- to postintervention (at the 0.05 level, same for all hypotheses).
TABLE 1. Demographics of participants.

<table>
<thead>
<tr>
<th>Age</th>
<th>&lt;60</th>
<th>60–69</th>
<th>70–79</th>
<th>80–89</th>
<th>≥90</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of participants</td>
<td>4.8</td>
<td>44.0</td>
<td>37.5</td>
<td>12.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Primary racial group</td>
<td>Asian</td>
<td>Black/African American</td>
<td>Latino</td>
<td>White</td>
<td>Other</td>
</tr>
<tr>
<td>% of participants</td>
<td>3.0</td>
<td>66.1</td>
<td>3.0</td>
<td>25.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Education</td>
<td>&lt;high school</td>
<td>High-school graduate/GED</td>
<td>Vocational training</td>
<td>Some college/associate's degree</td>
<td>Postgraduate training</td>
</tr>
<tr>
<td>% of participants</td>
<td>5.3</td>
<td>30.2</td>
<td>5.9</td>
<td>32.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Health</td>
<td>Poor</td>
<td>Fair</td>
<td>Good</td>
<td>Very good</td>
<td>Excellent</td>
</tr>
<tr>
<td>% of participants</td>
<td>0.6</td>
<td>16.5</td>
<td>56.5</td>
<td>22.9</td>
<td>3.5</td>
</tr>
<tr>
<td>Yearly household income</td>
<td>$&lt;20,000</td>
<td>$20,000–$29,999</td>
<td>$30,000–$39,999</td>
<td>$40,000–$49,999</td>
<td>$≥50,000</td>
</tr>
<tr>
<td>% of participants</td>
<td>33.1</td>
<td>0.6</td>
<td>15.7</td>
<td>13.9</td>
<td>14.4</td>
</tr>
</tbody>
</table>

*The remaining participants reported they did not know for certain (6%) or did not wish to answer this question (16.3%).

H2: General computer/Internet skill level increases significantly from pre- to postintervention.

H3: e-Health literacy increases significantly from pre- to postintervention.

H4: Self-esteem increases significantly from pre- to postintervention.

H5: Self-efficacy increases significantly from pre- to postintervention.

H6: Attitude toward psychological loss decreases significantly from pre- to postintervention.

H7: Attitude toward physical change increases significantly from pre- to postintervention.

H8: Attitude toward psychological growth increases significantly from pre- to postintervention.

H9: Computer anxiety decreases significantly from pre- to postintervention.

H10: Computer interest increases significantly from pre- to postintervention.

H11: Computer efficacy increases significantly from pre- to postintervention.

H12: Attitude toward the CL method improves significantly from pre- to postintervention.

Method

Research Sites

The Hyattsville and New Carrollton Branch Libraries of the Prince George’s County Memorial Library System (PGCMLS) served as the research sites for this study. PGCMLS is a publicly funded, urban library system serving nearly 830,000 residents in Prince George’s County, Maryland. It provides free, high-speed Internet access for public use. The Hyattsville and New Carrollton Branch Libraries provided networked computers, space, and staff support to facilitate implementation of this study. These libraries were selected as the research sites for this study for two main reasons. First, both serve a large population of ethnic minorities, ensuring the impact of this e-health literacy intervention on these minority groups. Second, the geographic location of each branch library is convenient to potential research participants and the researchers. Both libraries are easily accessible by car or public transportation (metro and bus), and both are within 10 miles of the university.

Participants

Standard recruitment techniques were used to recruit participants. These techniques included posting recruitment flyers in the library sites and other local organizations (e.g., senior centers) and advertising in the library system’s newsletter as well as in local newspapers (Currently, there is no consensus in the literature regarding the definition of “older adults.” In this study, the recruitment materials specified “age 60 and above” as the inclusion criterion for participation since this is one of the most commonly used cutoff points for defining older adulthood; e.g., Williamson, 1998. However, in the few cases where individuals under the age of 60 specifically requested to participate and when seats were available at the time, these individuals also were included in the study.)

A total of 172 older adults between the ages of 52 to 91 (M = 70.4, SD = 8.0) participated in this study during August 2009 to June 2010; 111 of them completed the 4-week intervention (retention rate = 65%). Most participants were women (71%), African Americans (66%), or had at least a high-school education (95%). One third of the participants had yearly household incomes of less than $20,000. A notable portion of the participants (8%) were nonnative English speakers (Table 1).

A majority of participants had limited prior experience with computers and the Internet (Table 2). One fourth of the participants had never used any of the 20 basic computer/Internet operations (e.g., open a Web browser, scroll horizontally, click on links) or were unsure of what those operations were. Half of the participants had never used at least 11 of the 20 operations or were not sure what they were. Two thirds of participants had not frequently used any of these operations. Only 10% of the participants frequently used at least half of these operations.

Measures

Adapted from existing outcome measures of CL (that focus on younger learners in formal educational settings) and with
necessary modifications, outcome measures (i.e., dependent variables) for this study covered the following categories: knowledge/skill gains, psychological adjustment to later life, and attitudes. Prior experience with peers and with computer technology and basic demographics were measured to serve as control variables (Copies of the instrument are available upon request to the author.)

Knowledge/skill gains.

- **General computer/Web knowledge** is measured by objective tests of knowledge about components of the computer (e.g., keyboard, mouse) and the Web (e.g., link, scroll bar). Computer knowledge and Web knowledge were each measured by five items; each item scored 1 point if answered correctly and 0 if answered incorrectly (scoring range = 0–5).

- **General computer/Web skill** is measured by procedural tests that require participants to carry out specific computer/Web operations (e.g., Open a Web browser; Go to the NIHSeniorHealth.gov Web site; Increase text size; Find information on the Falls and Older Adults health topic; Open a video). Two scores were recorded: (a) the number of successfully completed operations and (b) the number of assistances provided. For the number of successfully completed operations, there were a total of 30 operations, and each operation scored 1 point if successfully completed and 0 if unsuccessful (scoring range = 0–5). For the number of assistances provided, each assistance was counted as 1 point. Only three operations were allowed to provide assistance (These were operations necessary for transitioning to the next site/page to complete the next several operations on that site/page; e.g., Go to the NIHSeniorHealth.gov Web site.) (scoring range = 0–3).

- **e-health literacy efficacy** is measured by the 8-item e-health literacy scale (Norman & Skinner, 2006a); each item is rated on a Likert scale of 1 to 5 (1-strongly disagree, 2-disagree, 3-undecided, 4-agree, 5-strongly agree); a higher score indicates higher e-health literacy efficacy. Building on the self-efficacy concept (Bandura, 1986), the e-health literacy scale measures perceived skills at and comfort with using the Internet for health information and decision making (e.g., “I know how [emphasis in original] to find helpful health resources on the Internet”). This scale has been used in multicultural samples and has shown excellent internal consistency reliability (α = 0.89–0.97) with good test-retest reliability (Norman, 2009).

- **e-Health literacy supplemental measures.** The e-Health Literacy Scale (Norman & Skinner, 2006a) includes two supplemental items that measure (a) perceived usefulness of the Internet in helping make health decisions and (b) perceived importance of being able to access health resources on the Internet. Both items are rated on a Likert scale of 1 to 5 (for perceived usefulness: 1-not useful at all, 2-not useful, 3-unsure, 4-useful, 5-very useful; for perceived importance: 1-not important at all, 2-not important, 3-unsure, 4-important, 5-very important); higher score indicates higher perceived usefulness or importance.

- **Changes in health behavior/decision making** are measured by 12 items, including six items modified from a Kaiser Family Foundation survey (2005), five items modified from a PEW Internet study (Fox, 2006), and an additional item added to supplement the Kaiser and PEW items: “Have you changed the way you take medicine because of information you found on the NIHSeniorHealth.gov and MedlinePlus.gov Web sites?”

- **Learning effort** is measured using an item adapted from the National Survey of Student Engagement (NSSE; Pace & Kuh, 1998): “During the past four weeks, on average, how many hours per week did you spend on preparing for this computer class? (e.g., read the handouts, do the take-home assignment, and other activities related to this computer class).”

Psychological adjustment to later life.

- **Global (personal) self-esteem.** Most self-esteem measures focus on individuals’ self-evaluations of their personal identity (Luhtanen & Crocker, 1992). In this study, personal self-esteem was measured using the Single-Item Self-Esteem Scale (SISE; Robins, Trzesniewski, Tracy, Gosling, & Potter, 2002). Participants rated the item “I see myself as someone who has high self-esteem” on a Likert scale of 1 (disagree strongly) to 5 (agree strongly). The SISE Scale has an estimated reliability of 0.75 and strong convergent validity (Disattenuated correlations ranged from 0.91–0.99 ) and high correlation (range = 0.74–0.80) with the 10-item Rosenberg Self-Esteem Scale that also measures global self-esteem (Robins, Hendin, & Trzesniewski, 2001). The SISE Scale has been used in a diverse range of age groups, including the older population (Robins et al., 2002).

- **Global self-efficacy.** Adapted from the Self-Efficacy Scale, which was developed to assess efficacy in eight domains of living (Rodin & McAvay, 1992). Four of these eight items (transportation, financial situation, safety, and living arrangement) were not particularly relevant to the scope of this study and were dropped. The remaining four items (keeping healthy, having good relationships with family, with friends, and being productive) were included in a modified version of the Self-Efficacy Scale. Each item was on a Likert scale of 1 to 4 (1-strongly agree, 2-agree, 3-undecided, 4-disagree, 5-strongly disagree); the average score of all four items was used for final analysis; higher score indicates higher self-efficacy.
Attitude.

- Attitudes toward computers, including computer anxiety, interest, and efficacy are measured by the Computer Anxiety Scale (Gressard & Loyd, 1986; Loyd & Gressard, 1984; Woodrow, 1991) and the Computer Efficacy and Interest Subscales of the Attitudes Toward Computers Questionnaire (Jav & Willis, 1992) [e.g., “Computers do not scare me at all” (anxiety); “Reading or hearing about computers would be (is) boring” (interest); “I know that if I worked hard to learn about computers, I could do well” (efficacy)].

- Attitudes toward the CL method.

- Attitudes toward the class.

- Prior experience.

- Prior experience with peers is measured by the following item: “Are you related to or familiar with at least one person taking this same computer class? (e.g., spouse, sibling, friend, acquaintance)”

- Prior computer experience is measured by the duration and frequency of prior computer/Internet use.

Basic demographics.

- Age, gender, education, health status, race/ethnicity, income, primary language were the demographic items considered.

Instructional Materials

The instructional material used in this study was the “Helping Older Adults Search for Health Information Online: A Toolkit for Trainers” developed by the National Institute on Aging of the National Institutes of Health (NIH). This freely available Toolkit (http://nihseniorhealth.gov/toolkit/toolkit.html) is designed to improve older adults’ ability to seek, find, understand, and apply the health information provided by two NIH Web sites, NIHSeniorHealth and MedlinePlus. The Toolkit features detailed lesson plans, in-class interactive exercises, take-home practice exercises, and other supportive handouts (e.g., glossary of computer terms). The Toolkit contains nine modules, with Modules 1 to 5 focusing on NIHSeniorHealth and Modules 6 to 8 focusing on MedlinePlus. These eight modules were used in the eight sessions of the intervention (on average, one module per session). Module 9 focuses specifically on improving the ability to appraise health information and was used as an extra lesson plan when needed (i.e., when all or most of the participants in a class had more prior computer experience and were able to learn fast). Together, these modules help cover the e-health literacy skills as defined by Norman and Skinner (2006b).

Procedure

In Session 1, participants first signed the consent form (approved by the Institutional Review Board of the University of Maryland), then the pre-intervention testing was administered. The training intervention began with the completion of the pre-intervention testing. At the end of Session 8, the postintervention testing was administered. Each class met at a library site twice a week, 2 hr each time between 9:00 to 11:00 a.m., for a total of 4 weeks. Class size was small (no more than 8 participants per class). The instructor, a Master of Library Science student, frequently provided immediate, positive, and useful feedback whenever needed. Each participant had one computer to work on during each session. Instructors emphasized hands-on practice and provided relevant handouts during each session.

Collaboration was encouraged throughout the intervention. Inspired by the common strategies used to promote CL among younger adults in formal learning settings (Johnson et al., 1998, 2007), and adapting those strategies to accommodate the special needs and preferences of older adult learners in the public library setting, a number of strategies were used during the sessions to ensure CL. These included:

- At the beginning of each session, the instructor stated explicitly that the class should learn together as a group and encouraged all group members to share with and help each other.

- During the lecture, the instructor paused periodically (e.g., every 15 min or so) and gave participants about 2 min during each pause to compare notes with peers and reflect together.

- Participants were encouraged to ask questions, discuss, and try to answer peers’ questions.

- Participants were asked to work with peers to perform the hands-on practice activities.
TABLE 3. Dependent t-test results.

<table>
<thead>
<tr>
<th>Category of measures</th>
<th>Variable</th>
<th>Pre</th>
<th>Post</th>
<th>t(df)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge/skill gains</td>
<td>Computer knowledge</td>
<td>3.36, 1.24</td>
<td>4.13, 1.15</td>
<td>-5.26(106)**</td>
</tr>
<tr>
<td></td>
<td>Web knowledge</td>
<td>2.63, 2.09</td>
<td>4.31, 1.31</td>
<td>-8.23(105)**</td>
</tr>
<tr>
<td></td>
<td>General computer/Web knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. of successfully completed procedural tasks</td>
<td>12.61, 7.07</td>
<td>21.14, 5.50</td>
<td>-10.29(82)**</td>
</tr>
<tr>
<td></td>
<td>No. of assistances provided</td>
<td>1.99, 0.94</td>
<td>0.65, 0.79</td>
<td>11.47(82)**</td>
</tr>
<tr>
<td></td>
<td>General computer/Web skill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. of assistances provided</td>
<td>12.14, 7.07</td>
<td>21.14, 5.50</td>
<td>-10.29(82)**</td>
</tr>
<tr>
<td></td>
<td>e-health literacy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>e-health literacy efficacy</td>
<td>2.59, 0.83</td>
<td>4.04, 0.49</td>
<td>-16.59(106)**</td>
</tr>
<tr>
<td></td>
<td>Perceived usefulness of the Internet in helping make health decision</td>
<td>3.91, 1.05</td>
<td>4.62, 0.58</td>
<td>-6.29(98)**</td>
</tr>
<tr>
<td></td>
<td>Perceived importance of being able to access health resources on the Internet</td>
<td>4.33, 0.76</td>
<td>4.66, 0.54</td>
<td>-4.03(101)**</td>
</tr>
<tr>
<td>Psychological adjustment to later life</td>
<td>Global self-esteem</td>
<td>3.93, 0.91</td>
<td>4.09, 0.85</td>
<td>-1.78(93)</td>
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<td></td>
<td>Global self-efficacy</td>
<td>2.94, 0.56</td>
<td>3.07, 0.63</td>
<td>-1.76(94)</td>
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<tr>
<td>Attitude</td>
<td>Attitudes toward computers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Computer anxiety</td>
<td>2.24, 0.61</td>
<td>2.05, 0.69</td>
<td>2.49(92)*</td>
</tr>
<tr>
<td></td>
<td>Computer interest</td>
<td>4.32, 0.46</td>
<td>4.40, 0.61</td>
<td>-1.25(83)</td>
</tr>
<tr>
<td></td>
<td>Computer efficacy</td>
<td>4.13, 0.51</td>
<td>4.24, 0.61</td>
<td>-1.75(107)</td>
</tr>
<tr>
<td></td>
<td>Attitudes toward the aging experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physical change</td>
<td>14.62, 4.32</td>
<td>14.56, 4.34</td>
<td>0.12(92)</td>
</tr>
<tr>
<td></td>
<td>Psychological growth</td>
<td>27.32, 5.78</td>
<td>28.48, 5.72</td>
<td>-2.23(97)*</td>
</tr>
<tr>
<td></td>
<td>Attitude toward the Collaborative Learning method</td>
<td>31.36, 4.14</td>
<td>31.77, 4.61</td>
<td>-0.90(90)</td>
</tr>
</tbody>
</table>

* p < 0.05. ** p < 0.01. *** p < 0.001.

- Participants were encouraged to pose real-life questions or problems. The group worked together to discuss the questions/problems and develop solutions.
- During the last 10 min of each class session, participants sat in a circle to discuss, share, and reflect together.

Results

Changes From Pre- to Postintervention

Dependent t tests of variables measured in both the pre- and postintervention tests showed strong, significant differences from pre to post in all variables in the category of knowledge/skill gains: computer and Web knowledge and skills, e-health literacy efficacy, perceived usefulness of the Internet in helping make health decisions, and perceived importance of being able to access health resources on the Internet (all ps < 0.001). H1, H2, and H3 were strongly supported. Significant differences also were found from pre to post in three of the attitude measures: computer anxiety and attitudes toward the aging experience in physical change (both ps < 0.05) and attitude toward the CL method (p < 0.01). H7, H9, and H12 also were supported. No significant difference was found from pre to post in all other variables: self-esteem, self-efficacy, computer interest and efficacy, and psychosocial loss and psychological growth in attitudes toward the aging experience. H4, H5, H6, H8, H10, and H11 were not supported (Table 3).

Effect sizes (measured by Cohen’s d) with regard to the variables of gains in general computer and Web knowledge and skill and e-health literacy ranged from 0.5 to 2.1. The statistical power of these measures reached 1.00 or 0.99 even at the α = 0.01 level. Effect sizes with regard to the other three variables that showed significant differences (all in the attitude category)—computer anxiety, attitudes toward the aging experience in physical change, and attitude toward the CL method—were 0.29, 0.20, and 0.30, respectively, with statistical power of 0.69, 0.38, and 0.81, respectively, at the α = 0.05 level (Table 4).

Learning Effort

During the past 4 weeks, 19% of participants had spent on average more than 3 hr a week preparing for the computer class (e.g., reading the handouts, doing the take-home assignment), 32% spent 1 to 2 hr a week, 30% spent less than 1 hr but more than a half hour a week, and 13% spent less than a half hour a week. Six percent of participants reported had never spent any time preparing for the computer class.

No significant partial correlation was found between learning effort and each of the following postintervention measures after controlling for each of these variables at the baseline level, respectively: general computer/Internet knowledge and skill, perceived usefulness of the Internet in helping make health decision, self-esteem, self-efficacy, attitudes toward the aging experience, computer attitudes. Significant partial correlation was found between learning effort and e-health literacy efficacy, after controlling for baseline e-health literacy efficacy (p < 0.05). Significant partial correlation also was found between learning effort and perceived importance of being able to access health resources on the Internet, after controlling for the perceived importance variable at the baseline level (p < 0.05).
### Table 4. Effect sizes and statistical power.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cohen’s <em>d</em></th>
<th>Percentile standing</th>
<th>Power (<em>α</em> = 0.05)</th>
<th>Power (<em>α</em> = 0.01)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer knowledge</td>
<td>0.6</td>
<td>73</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Web knowledge</td>
<td>1.0</td>
<td>84</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>No. of successfully completed procedural tasks</td>
<td>1.4</td>
<td>92</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>No. of assistances provided</td>
<td>-1.5</td>
<td>93</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>e-health literacy scale (e-health literacy efficacy)</td>
<td>2.1</td>
<td>98</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Perceived usefulness of the Internet in helping make health decision</td>
<td>0.8</td>
<td>79</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Perceived importance of being able to access health resources on the Internet</td>
<td>0.5</td>
<td>69</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>Computer anxiety</td>
<td>0.3</td>
<td>62</td>
<td>0.69</td>
<td>0.44</td>
</tr>
<tr>
<td>Attitudes toward the aging experience: Physical change</td>
<td>0.2</td>
<td>58</td>
<td>0.38</td>
<td>0.18</td>
</tr>
<tr>
<td>Attitude toward the Collaborative Learning method</td>
<td>0.3</td>
<td>62</td>
<td>0.81</td>
<td>0.60</td>
</tr>
</tbody>
</table>

### Table 5. Attitudes toward the intervention.

<table>
<thead>
<tr>
<th>Instructor’s teaching</th>
<th>Very poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of participants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall usefulness of the class</td>
<td>Completely useless</td>
<td>Useless</td>
<td>Somewhat useful</td>
<td>Useful</td>
<td>Very useful</td>
</tr>
<tr>
<td>% of participants</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Overall experience in the class</td>
<td>Extremely dissatisfied</td>
<td>Dissatisfied</td>
<td>Neither satisfied nor dissatisfied</td>
<td>Satisfied</td>
<td>Extremely satisfied</td>
</tr>
<tr>
<td>% of participants</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>27</td>
<td>72</td>
</tr>
<tr>
<td>If started over, willingness to take the same class</td>
<td>Definitely not</td>
<td>Probably not</td>
<td>Not sure</td>
<td>Yes</td>
<td>Definitely yes</td>
</tr>
<tr>
<td>% of participants</td>
<td>1</td>
<td>2</td>
<td>13</td>
<td>28</td>
<td>56</td>
</tr>
<tr>
<td>Would recommend the class to age peers</td>
<td>Definitely not</td>
<td>Probably not</td>
<td>Not sure</td>
<td>Yes</td>
<td>Definitely yes</td>
</tr>
<tr>
<td>% of participants</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>22</td>
<td>77</td>
</tr>
</tbody>
</table>

### Table 6. Impact of the intervention on health-related behavior and decision making (% of participants).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Since started taking this computer class, have had a conversation with a friend or family member about the health information found on the NIHSeniorHealth.gov and MedlinePlus.gov Web sites</td>
<td>83</td>
<td>16</td>
</tr>
<tr>
<td>Since started taking this computer class, have talked with a doctor or other healthcare provider about the information found on the two sites</td>
<td>25</td>
<td>74</td>
</tr>
<tr>
<td>Have changed behavior because of the health information found on the two sites</td>
<td>66</td>
<td>34</td>
</tr>
<tr>
<td>Have made a decision about how to treat an illness or condition because of the information found on the two sites</td>
<td>67</td>
<td>33</td>
</tr>
<tr>
<td>Have changed health insurance plan because of the information found on the two sites</td>
<td>2</td>
<td>95</td>
</tr>
<tr>
<td>Have changed overall approach to maintaining own health or the health of a loved one because of the information found on the two sites</td>
<td>74</td>
<td>26</td>
</tr>
<tr>
<td>Information learned from the two sites has led to ask a doctor new questions or to get a second opinion from another doctor</td>
<td>47</td>
<td>52</td>
</tr>
<tr>
<td>Information found on the two sites has changed the way think about diet, exercise, or stress management</td>
<td>84</td>
<td>16</td>
</tr>
<tr>
<td>Information found on the NIHSeniorHealth.gov and MedlinePlus.gov Web sites has changed the way coping with a chronic condition or manage pain</td>
<td>62</td>
<td>38</td>
</tr>
<tr>
<td>Information found on the NIHSeniorHealth.gov and MedlinePlus.gov Web sites has affected a decision about whether to see a doctor</td>
<td>45</td>
<td>54</td>
</tr>
<tr>
<td>Have changed the way taking medicine because of the information found on the two sites</td>
<td>48</td>
<td>51</td>
</tr>
</tbody>
</table>

**Attitudes Toward the Intervention**

Participants were highly positive about various aspects of the intervention (Table 5).

**Changes in Health Behavior and Decision Making**

The majority of participants (71%) reported that the information found on the NIHSeniorHealth.gov and MedlinePlus.gov Web sites helped them “a lot” with taking care of self or a loved one. Another 23% of participants reported such information helped “somewhat,” and 6% reported such information helped “only a little.” No one reported such information helped “not at all” for taking care of self or a loved one. Other indicators in this category are reported in Table 6.

**Group Composition Based on Gender, Familiarity With Peer, and Prior Computer Experience**

Group gender composition included four groups: groups with female majority, equal number of female and male, male majority, and female only. (There was no male-only group.)
Group composition based on familiarity with peers included two groups: familiar with at least one other person in the same class and not familiar with anyone in the same class. Multivariate analysis of covariance (MANCOVA) showed no significant difference in any of the postintervention outcome measures for participants in the four groups with different gender composition or for participants in the two groups with different familiarity composition, after controlling for baseline general computer/Internet knowledge and skills, e-health literacy, self-esteem, self-efficacy, attitudes toward the aging experience, and computer attitudes.

While the categorization for these two types of group composition was straightforward, the categorization for group composition based on prior computer/Internet experience required extra steps. First, MANCOVA was performed and found no significant difference in postintervention computer anxiety, interest, and efficacy among participants of varying computer use duration and Internet-use duration, after controlling for baseline computer anxiety, interest, and efficacy. Significant differences were found in postintervention computer anxiety, interest, and efficacy ($p < 0.05$, $0.01$, and $0.001$, respectively) among participants with varying computer use frequency. Significant differences also were found in postintervention computer interest and efficacy ($p < 0.05$ and $0.01$, respectively) among participants with varying Internet use frequency; however, no significant difference was found in computer anxiety among participants with varying Internet use frequency, after controlling for baseline computer anxiety, interest, and efficacy.

Based on these results, computer use frequency was then used to categorize group composition based on prior computer experience. For the purpose of this study, “experienced computer users” were defined as those who use computers every day or every 2 to 3 days a week, and “inexperienced computer users” were defined as those who use computers less than every 2 to 3 days a week. Using this criterion, each computer-class group was coded into one of the following four groups to reflect group composition based on prior computer experience: groups with experienced user majority, inexperienced user majority, equal number of experienced and inexperienced users, and all inexperienced users. MANCOVA found no significant difference in any of the postintervention outcome measures in participants in these four groups with different prior computer experience composition, after controlling for baseline general computer/Internet knowledge and skills, e-health literacy, self-esteem, self-efficacy, attitudes toward the aging experience, and computer attitudes.

Participants Who Completed the Intervention Versus Those Who Did Not

Independent $t$ tests of participants who completed both the pre- and posttesting ($n = 111$) and those who completed only the pretesting show there is no significant difference between these two groups in age, gender, education, race, yearly household income, language, prior computer/Internet experience, baseline general computer/Internet knowledge and skills, e-health literacy, self-esteem, self-efficacy, attitudes toward the aging experience, or computer attitudes. However, a significant difference was found between these two groups in self-reported health status: Participants who completed the 4-week intervention reported being healthier than those who did not ($p < 0.05$).

Discussion

It is well documented that low health literacy has significant negative effects on health outcomes and the cost of healthcare. Also well documented are the main reasons for the nationwide health illiteracy crisis: Patients’ lack of education and medical professionals’ high expectations for patients’ health literacy (Institute of Medicine, 2004). However, little is known about effective health literacy interventions (What really works?) and implementation strategies (How do we do it?) (Mika, Kelly, Price, Franquiz, & Villarreal, 2005). Even less is known about the relative effectiveness of different interventions on different individuals (e.g., older vs. younger adults). As part of the aging process, older adults generally have a great need for health information and services; unfortunately, their health literacy levels are low (Kutner et al., 2006). The older population possesses an especially great need for health literacy interventions.

Due to age-associated changes in cognition, physiology, and social environments, health literacy interventions targeting younger people (e.g., health educational programs in schools) are unlikely to reach or yield similar results in the older population. Further, existing health literacy interventions focus primarily on making medical materials and instructions easy to understand by the general public (Andrus & Roth, 2002; Parker & Kreps, 2005; Schaefer, 2008). Due to the complexity of medical terminology and knowledge, this “lowering the bar” approach can help solve the problem only to some extent. Raising the actual health literacy level through education and training is another key approach to addressing the health illiteracy problem (Kickbusch, 2004). This requires an understanding of developing health literacy through an active, lifelong learning process that goes beyond the formal educational settings in early life stages. This process should feature the continuous learning of new, valid information and the “unlearning” of outdated, harmful information (Kickbusch, 2004). Such an understanding is especially important in the context of information and communication technologies being increasingly used by health consumers and professionals in healthcare (Institute of Medicine, 2009; Oh et al., 2005). As Norman (2009) correctly noted, as technology changes, so do the requirements for health literacy skills.

Developing effective learning interventions to improve older adults’ health literacy requires a thorough understanding of older adults’ needs and preferences. This will require looking beyond the new field of health literacy and drawing from the broad range of existing theories on adult learning. CL that centers on active social interaction is highly effective among young adult learners, as predicted by the social...
interdependence theory (Johnson et al., 1998, 2007) and supported by ample empirical data (Johnson et al., 2007). This emphasis on social interaction matches well with the author’s prior work on older adults’ computer learning that shows the social, collaborative process of learning to use computers (e.g., peer learning, friendship development) being perhaps as important as the learning outcomes (Xie, 2007a, 2007c, 2008c; Xie & Jaeger, 2008). Similar findings were reported in other studies (for a review, see Dickinson & Gregor, 2006), though the researchers who conducted these other studies did not expect such findings (Billipp, 2001; Bradley & Poppen, 2003; Eilers, 1989; Karavidas et al., 2005; White et al., 2002).

Building onto, integrating, and expanding these prior lines of research, the present study examined whether and how CL might be a useful method in improving older adults’ e-health literacy. The results show strong, statistically significant differences from pre- to postintervention in all variables in the category of gains in general computer/Web knowledge and skills and in e-health literacy (all ps < 0.001). Effect sizes of the intervention on these variables ranged from medium to large according to Cohen’s (1988) arbitrary categorization that labeled effect sizes of 0.2, 0.5, and 0.8 as small, medium, and large, respectively. What these results mean is that for instance, with respect to gains in general computer skills, an effect size of 1.4 means that a learner increased from the 50th percentile on the pretest to the 92nd percentile on the posttest. In terms of e-health literacy efficacy, an effect size of 2.1 means that a learner improved from the 50th percentile on the pretest to the 98th percentile on the posttest on this measure. The statistical power of all these measures was extremely strong (1.00 or 0.99), even at the $\alpha = 0.01$ level, adding to the strength of these positive results.

These results are not to be taken lightly, considering that (a) several meta analyses of existing studies on CL (in younger learners in formal educational settings) have consistently found effect sizes ranging from 0.29 to 0.70 (Johnson, Johnson, & Smith, 1991; Johnson et al., 1998; Springer, Stanne, & Donovan, 1999), and (b) in general, “effect sizes of 0.8 are rare for any [learning] intervention and require truly impressive gains” (Prince, 2004, p. 24). In the present study, with five of the seven variables in the knowledge/skill gains category showing greater than 0.8 effect sizes (The remaining two had effect sizes of 0.6 and 0.5, respectively), the intervention has indeed shown “truly impressive gains” in these variables. These findings provide strong support for the effectiveness of the CL strategies used in this study, which were developed based on prior research (Johnson et al., 1998, 2007) and modified to accommodate the special population and setting of this study. These findings suggest that social interdependence theory can be generalized beyond the younger population and formal educational settings. The findings also suggest that these particular outcome measures are sensitive to measuring the effects of CL among older learners in an informal learning setting.

Attitude toward the CL method changed significantly from pre- to postintervention toward stronger preference for CL ($p < 0.01$; effect size: 0.30; power: 0.81 at the 0.05 level). The item used to assess this type of attitude was used in a prior experimental study, the only known study that has examined CL among older computer users (Zandri & Charness, 1989), which found that attitude toward the CL method at the baseline had no impact on learning outcomes. One possible reason, as suggested by the present study, is that such an attitude is sensitive to the CL intervention and thus not ideal to serve as a control variable that is supposed to remain stable (Zandri & Charness did not measure this variable at postintervention.) It would be interesting in future research to examine whether other learning methods (e.g., individualistic learning) might have similar effects on learners’ attitude toward the learning method.

Significant differences were found from pre- to postintervention in two additional attitude measures: computer anxiety and attitudes toward the aging experience in physical change (both $p < 0.05$). However, effect sizes with regard to both of these measures were small, and statistical power was below the commonly accepted power level of 0.80 for both measures. These indicators suggest that the impact of the intervention on these two variables may be weak. No significant difference was found from pre- to postintervention in all other variables: (global) self-esteem and self-efficacy, computer interest and efficacy, and attitudes toward the aging experience in psychosocial loss and psychological growth; however, note that there were still observable trends in positive changes in all these other variables from pre- to postintervention. Because the number of participants who were included in the dependent $t$ tests on these variables was relatively small (see Table 3), it is possible that with a larger sample, significant differences might be detected in these variables. This also suggests that these measures are not as sensitive in detecting effects of this intervention as are the knowledge/skill measures (that involved similar sample size and yet still detected significant differences).

But it also is possible that the intervention is not effective in affecting these constructs. One possible reason may be ceiling effects. For instance, participants of this study already had high levels of computer interest and efficacy at baseline (Mean computer interest and efficacy was 4.32 and 4.13, respectively, on a Likert scale of 5 (highest level of interest or efficacy), making it unlikely for any intervention to generate significant improvements on these scales. In comparison, participants’ baseline computer knowledge and skills and e-health literacy were at relatively low levels, leaving more room for significant improvements. This potential reason matches well with the profile of the participants, who were self-selected to participate in this study (indicating positive attitudes toward computers) but also had very limited prior computer experience. It will be interesting in future research to examine and compare the effectiveness of this intervention on individuals who have more prior computer experience and higher e-health literacy at the baseline than did participants of this study. Such a future direction may help
understand whether this intervention will work for learners with varying prior experience/literacy level or will work only on those who have limited prior experience/literacy level.

How much time a learner spends on course preparation (i.e., learning effort) is considered a key indicator of learning success for younger learners in formal educational settings such as colleges (Pace & Kuh, 1998). In the present study, while significant correlation was found between learning effort and two of the measures (e-health literacy efficacy and perceived importance of being able to access health resources on the Internet), no significant correlation was found between learning effort and the other outcome measures. One possible reason is that compared with college students who reported spending more time on course preparation (Kuh, 2003), in the present study participants reported spending limited preparation time outside of the program, which then led to the findings that the relationships between learning effort and the majority of the outcome measures were insignificant. Participants’ limited amount of outside effort might be a result of them lacking convenient access to computers at home, considering that the majority of participants had no or limited prior computer experience and that a notable portion of them had limited income. If this is the case, future interventions should provide ample opportunities for participants to access computers and practice beyond the timeframe of the intervention.

Participants’ attitudes toward various aspects of the intervention were highly positive (see Table 5), adding to the positive results from the objective measures of knowledge/skill tests and providing further evidence for the effectiveness of the intervention. Furthermore, an important aspect of the health literacy concept is the ability to use the health information obtained to make health decisions and, subsequently, change health-related behaviors (U.S. Department of Health and Human Services, 2000). The results were highly positive in this regard as well (see Table 6). These findings suggest that this intervention is useful in leading to changes in health-related behavior and decision making. These findings are of critical importance in the contemporary healthcare system, where patients are increasingly expected to take more responsibility for their own healthcare (Ballard-Reisch, 1990; Benbassat, Pilpel, & Tidhar, 1998; Brody, 1980; Jones & Phillips, 1988; McNutt, 2004; Xie, 2009).

As reviewed earlier, prior research has provided limited, inconclusive results about the impact of group composition on CL outcomes. In the present study, after controlling for baseline differences, no significant difference was found in any of the outcome measures among individuals in different group compositions (based on gender, familiarity with peers, and prior computer experience), suggesting that these three group-composition factors had no impact on CL outcomes. These findings seem to contradict some prior studies that have found evidence for the impact of group-gender composition on CL (Busch, 1996; Maskit & Hertz-Lazarowitz, 1986; Underwood et al., 1990), the impact of group composition based on familiarity with peers (Andersson & Ronnberg, 1995, 1996; Gould et al., 1994; Margrett & Marsiske, 2002), and the impact of group composition based on prior experience (Campion et al., 1993; Johnson & Johnson, 1999; Pearce & Ravlin, 1987; Webb & Palincsar, 1996). However, the findings of this study are consistent with other research that did not find any impact of familiarity with peers (Margrett & Willis, 2006) or group composition based on prior experience (Wang & Lin, 2007). Note, though, that the number of participants in each subgroup was relatively small and that the subgroup sizes were uneven (e.g., for group-gender composition, the subgroup sizes ranged from $n = 43$ in groups with a female majority to $n = 3$ in groups with a male majority; this is not a surprise, given that 71% of the participants were women). It is possible that with a larger sample and more even group size experimental design, significant differences in these variables might be detected. Further research is needed to generate more conclusive results about the impact of group composition on CL outcomes.

**Limitations and Future Directions**

This study has some limitations. The sample used in this study was not random. Caution should be taken when attempting to generalize the findings to other groups of older adults. However, note that this sample has its own strength: The majority of participants of this study were African Americans, and one third of the participants had annual household incomes of less than $20,000. These characteristics of the study sample match well with the expectations for urban public libraries to serve socially and economically disadvantaged individuals (Xie & Jaeger, 2008). Because individuals who belong to ethnic minority groups or have low incomes are likely to have low health literacy (Institute of Medicine, 2004; Kutner et al., 2006) and particularly low e-health literacy (Institute of Medicine, 2009), developing interventions based at public libraries, as this study did, may be a good way to influence these otherwise difficult to reach individuals.

Due to resource and logistical constrains, this study was able to examine only the CL experimental condition. While the effect size and power analyses as reported have provided strong evidence for the effectiveness of CL, it would be good in future research to compare and contrast the relative effects of CL and other learning methods (e.g., individualistic learning). The retention rate of study participants was 65%, a reasonable level given the 4-week duration of this intervention and that participants were not given any monetary incentive for participation. Still, in future research, it may be useful to further raise the retention rate (by, for instance, providing monetary incentive). Interestingly, demographic factors and baseline measures did not have significant effects on whether individuals would complete the program. Health appeared to be the only factor that significantly affected whether individuals would complete the intervention or leave early: Participants who completed the intervention reported being in healthier status than those who did not. This is not surprising, given that participants had to be mobile and healthy to be able to travel regularly to the library sites to
participate. These findings suggest the particular effectiveness of the intervention on healthy older adults while also calling for developing interventions attractive and effective to less healthy older adults.

Conclusion

This study generates strong evidence that CL can be a useful method for improving older adults’ e-health literacy when using the specific strategies developed for this study, suggesting that social interdependence theory can be generalized beyond the younger population and formal educational settings. Significant improvements were found from pre- to postintervention in knowledge and skill gains, including general computer and Web knowledge and skills and e-health literacy, as indicated by the statistical significance level (all $p < 0.001$), effect size (range $= 0.5–2.1$, with five of the seven effect sizes $> 0.8$), and statistical power (reached 1.00 in all but one case and 0.99 in the remaining case even at the $\alpha = 0.01$ level) with regard to each of these variables. The findings suggest these knowledge/skill-gain measures are more sensitive than are the other measures used in this study (self-esteem, self-efficacy, and attitudes) in measuring the effects of CL among older learners in an informal setting. This study also finds evidence in positive changes in health-related behavior and decision making, suggesting that the intervention is effective in helping participants translate health information into healthy behavior and decision making—a key indicator for improved health literacy. With regard to group composition, this study found no significant impact of group-gender composition, prior familiarity with peers, and prior computer experience on CL outcomes, though the relatively small and uneven sizes of the subgroups in each group composition might have contributed to these findings. Future research will benefit from examining the eHILL-CL intervention with an even group-size design to explore potential impact of group composition on CL outcomes and from examining the intervention with larger, representative samples, and then comparing these with the effects of other learning methods in a variety of informal learning environments (e.g., senior centers, assisted-living facilities).

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References


Institute of Medicine. (2004). Health literacy: A prescription to end con-


