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TEACHING GENERAL CHEMISTRY WITH INSTRUCTOR'S SCREEN SHARING: STUDENTS' OPINIONS ABOUT THE IDEA AND ITS IMPLEMENTATION

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Abstract. *Knowing students' opinions about instructor's screen sharing via various media is important for developing online science courses including chemistry. This study examined university students' opinions about the idea and the practice of instructor's screen sharing via websites on example of join.me, VoIP-applications on example of Skype, and multi-user 3D virtual environments on example of Second Life. It was conducted during summer course of General Chemistry at University of Oregon College of Arts and Sciences in Eugene, USA, for two consecutive years, 2001 and 2012. The data were collected through an online 14-item 4-point Likert-type questionnaire and students' reviews. It was found that students have primarily positive opinions about screen sharing regardless of their gender, major, residence, and employment status. Join.me was found to be the most and Second Life to be the least favored media for screen sharing. Students with higher final grades provided more positive opinions.*

Key words: *chemistry education, online teaching, screen sharing, Skype, Second Life.*

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Introduction

Being the central science (Brown, LeMay, Bursten, Murphy, Woodward, 2012), chemistry should be taught and studied in a special and effective way. Unlike some other disciplines, mostly humanities, chemistry has always required a writing participation. Consider the lecture aspect: while listening to the lecture and/or viewing its slides may be well enough to get the point in history or culture studies, it is quite insufficient to figure out chemistry. If one wants to become really proficient, s/he should repeatedly write chemical symbols, formulas, equations, etc. as s/he sees them either at a lecture or in a textbook – synchronously, and after the lecture or the textbook – asynchronously. Perhaps, neither of eight major subcategories of chemistry knowledge identified by introductory chemistry teachers (chemical language, atomic structure, molecular structure, properties of matter – the chemical structure domain; chemical reactions, kinetics, thermodynamics, and equilibrium – the chemical reactivity domain) (Talanquer, 2013, p.833) can be mastered without student's active writing, and often with instructor's writing participation. When it comes to the laboratory aspect, it is obvious that participation is a key: chemistry proficiency is nothing without analytical / synthetical – manual skills one can develop only by actual participation not merely viewing and listening.

Nowadays, ICT are widely used in science education and chemical education in particular. Its variety ranges from drill-and-practice software to multi-user 3D virtual immersive environments (Wankel & Kingsley, 2009). The author believes, however,

that whatever technological advances happen, the instructor (teacher, educator, trainer, lecturer, etc.) remains and will remain the central person in any academic process. On the one hand, ICT expansion in education is unstoppable as progress at all is objective and inescapable. On the other hand, as any technology, computer mediation alienates students from the instructor. It is common practice to lecture today continuously demonstrating slides developed in Power Point, and often lecturer just comments on them without any alteration on the fly. To make the presentation friendlier, lecturer should bring something personally dynamic to the static slides. And this personal can be his handwriting concurrent to the topic covered. Another way to minimize the alienation is for the instructor to share his computer screen with students, provided the latter have their own computers on.

Most publications (e.g. Udell, 2006; Wild & Wiggins, 2006; Ko, Lee, Kim, 2012; Pan, Shen, Lu, Li, Yu, 2013) focus on technical aspects of screen sharing. It can be done in a number of ways: various web-sites (join.me, screenleap.com, quickscreenshare.com, etc.), applications functioning as built-in VNC (virtual network computing)-clients of operation systems (Apple Screen Sharing) and as independent applications (Apple Remote Desktop, Crossloop, TeamViewer, Timbuktu, etc.), as a tool in VoIP (voice over Internet protocol)-based integrated packets (Skype, WebEx, Sococo, etc.). Screen sharing must be simple, reliable, flexible, distraction-free, and quick.

However, screen sharing is more than just a fashionable technology – it is a case of instructor-student real-in-the-virtual collaboration (Simpson & Rowland, 2009; McCrea, 2013). The interrelationship of emotion and cognition in collaborative learning was studied on example of psychology course (Robinson, 2012), students' attitudes towards online collaborative learning, their perception of online teamwork learning experiences were studied on example of instructional design course (Tseng & Yeh, 2012; Ku, Tseng, Akarasriworn, 2013).

Research findings on pedagogical and psychological aspects of screen sharing should be taken into consideration developing virtual laboratories and online chemistry classes. Although chemistry, just like medicine, cannot be taught totally online (Moore, 2008; Pienta, 2013), its many theoretical concepts can. Before teaching chemistry online, one should be aware of how students perceive screen sharing, essential component of this process.

Based on this rationale, the following research goals were defined:

- to study students' opinions about the idea of instructor's screen sharing via websites on example of join.me, via VoIP-applications on example of Skype, and via multi-user 3D virtual immersive environments on example of Second Life;
- to study students' opinions about the screen sharing practice in academic formal (lecture) and informal (consultation) settings on the specified media examples.

The author put forward a hypothesis that students' opinions about the idea of instructor's screen sharing and about its implementation would be positive. With respect to the gender psychology (Lawton, 2010), also a difference was supposed in male and female students' opinions, especially about 3D virtual environments where the spatial factor is involved.

Research Methodology

Looking for a representative research sample and a typical learning environment, summer college courses were addressed. Such courses including chemistry are offered at Boston, Columbia, Harvard, Santa Clara, Stony Brook, Washington and many other universities throughout the country. Taught in an accelerated way, they are popular among freshmen, sophomores, juniors and seniors of science- and non-science majors who choose chemistry to fill the requirement for a science class. This circumstance allows us to envision a sample compiled of summer students as representative of general student population.

Course

The General Chemistry summer sequence (University of Oregon, 2013) includes three lecture-only no-lab courses. They are designed for science majors and pre-professional students and provide

an introduction to the experimental and theoretical foundations of chemistry. Students gain factual knowledge about the terminology and language of chemistry as well as an understanding of the underlying reasons why chemical processes occur. The students are expected to interpret, reason and solve problems using fundamental chemical principles. Interwoven throughout the sequence is an emphasis on development of the problem solving skills fundamental for success in future science courses. Each course includes lectures, homework, three quizzes, and three exams.

Concentrated learning objectively poses a number of challenges (Shaw, O'Brien, Leicester, 2001) for students adjusting to the pace, having confidence in oneself to be able to meet the academic needs, being under pressure to achieve everything expected within the time available, articulating with real life afterwards, managing time. These feel even more intense for international students, whose English is a second language. Faculty also face challenges such as pressure of intense teaching on a course that comes at the end of the academic year, tension between developing learning while trying to meet the student requirement for "having everything delivered on a plate", and tension between delivering content and developing criticality.

The students enrolled must have completed at least one year of high school chemistry or the equivalent. Because of the time limit, the instructor emphasizes solving chemical problems integrating theoretical patterns with practical data handling. College algebra therefore is a co/pre-requisite for the sequence being intense in writing and math. Instructor's collaborative writing and, therefore, screen sharing is desirable for lectures and consultations.

Research Sample

The participants in this study were students enrolled in General Chemistry summer courses, CH221-223 taught by the researcher at University of Oregon College of Arts and Sciences in Eugene, USA, across two consecutive years – 2011 and 2012. Included in table 1 are students in the course roster (addends in parentheses – in 2011 and 2012, respectively).

Table 1. The initial research sample.

	Major						Total
	Science / Math *		Non-Science **		Undeclared or Community Education Program ***		
	Roster number	Percent	Roster number	Percent	Roster number	Percent	
Male Students	106 (54 + 52)	35.3	19 (7 + 12)	6.3	25 (14 + 11)	8.4	150 (75 + 75)
Female Students	94 (44 + 50)	31	30 (7 + 23)	10.	27 (15 + 12)	9.0	151 (66 + 85)
Total	200	66.3	49	16.3	52	17.4	301

* *Science/Math major: Biology, Biochemistry, Chemistry, Computer and Information Science, Environmental Science, Environmental Studies, General Science, Geological Sciences, Human Physiology, Mathematics, Physics;*

** *Non-Science major: Anthropology, Business Administration, Digital Arts, Economics, English, German, History, International Studies, Philosophy, Psychology, Spanish;*

*** *Community Education Program is a part-time, non-admitted student status that allows anyone to register for up to 8 credits a term without formal admission.*

Besides the listed, the majors included Pre-Marine Biology, Pre-Business Administration, Pre-Education, and Pre-Engineering. As the roster analysis showed, although most students taking summer chemistry were science majors (66.3%), only few of them were chemistry majors (4 chemistry and 8 biochemistry out of 301).

Because student participation in the research (questionnaire) was voluntary, the reduction of the research sample occurred each year that is illustrated by table 2. Roughly 1/10 of the students provided their feedback.

Table 2. The adjusted research sample.

	Major						Total
	Science / Math		Non-Science		Undeclared or Community Education Program		
	Participating number	Percent	Participating number	Percent	Participating number	Percent	
Male Students	15	41.7	2	5.6	2	5.6	19
Female Students	9	25	4	11.1	4	11.1	17
Total	24	66.6	6	16.7	6	16.7	36

Lectures Screen Shared via join.me

It was announced at the introductory meeting that the instructor's screen would be shared during lectures and consultations, the students were encouraged to bring their computers to the auditorium, to bookmark the screen sharing website and to download the screen sharing software.

The students had 84-90 2-hour lectures over three summer terms – 28-30 lectures per term. The topics in stoichiometry, quantum theory, periodic table, chemical bonding, states of matter, kinetics, equilibria, thermodynamics, electrochemistry, and nuclear reactions were covered in accordance with the syllabus and referring to the textbook (Silberberg, 2011).

The Power Point slides were designed as templates containing only parts of the tasks (chemical equations, problems, schemes, etc.) and saved as jpeg-images. The instructor used Paint Brush, a simple graphic editor, and Bamboo splash pen tablet to write on those template slides on his screen – to name a compound, to balance a reaction, to derive a formula, etc.

Daily, 5-10 min before the lecture, instructor connected to join.me, received a random screen sharing code and posted it to the Blackboard, the University of Oregon adopted course management system. He also announced it in the auditorium, so both present and absent students could access his screen via join.me using the code and a laptop or an iPad. The access included viewing of and instant messaging to the instructor's screen. Since the screen was projected in the auditorium, all the students were able to see those messages (questions, comments, etc.).

Consultations Screen Shared via Skype

Over the sequence, the students had 86 2-hour face-to-face consultations (office hours) with the instructor and his teaching assistants. Besides, they had 86 2-hour virtual consultations, of which one hour was scheduled for Skype sessions.

The instructor's Skype name was included to the syllabus. The sessions were held in the evening, serving one, sometimes more students per session in a conference call to consult with screen sharing. The instructor and the student or the students used voice to communicate, solving chemical problems together in such collaborative learning. OmniDazzle, an application for writing on the computer screen over any open window was used at online consultations, often in a browser window with open homework, diagram, thermodynamic data, etc. (Figure 1).

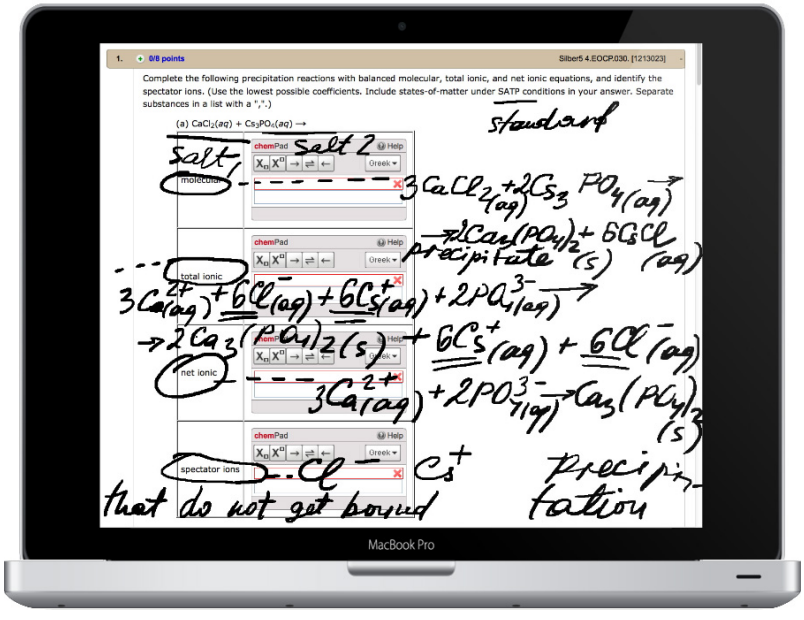

Figure 1: Virtual consultation in Skype with instructor's screen being shared full-screen. Instructor's handwritten explanations (molecular, total and net ionic equations) are over the homework assignment.

Consultations Screen Shared via Second Life

Of the two hours of daily virtual consultations, another one was scheduled for meetings with the instructor and his teaching assistants in Second Life. Four "public" accounts were registered for the students (*CH221-23student1* to *CH221-23student4*), their logins and passwords were included to the syllabus. Besides, students were encouraged to sign up for personal accounts to stay with Second Life in the future.

Second Life emerged as the most popular non-game based 3D world. Its users interact with the environment and with each other in the form of avatars; almost every aspect of real life including science education is replicated in Second Life. It was shown to be a valuable tool for conducting chemistry research, education, and collaboration (Bourke, 2009; Lang & Bradley, 2009, 2011a, 2011b; Pence, 2007). The next years, however, indicated the lack of explorations on some subject areas, such as chemistry and mathematics (Wang & Burton, 2013).

In recent years, the author used Second Life for developing models of atomic and molecular orbitals and illustrating molecular geometry (Slabin, 2010). It was our interest now to research on screen sharing in Second Life, possible because the environment has a built-in browser and one can run an Internet web page (in our case join.me) on any prim.

The consultations were held in virtual offices in the Alice Academy island (Layton, 2011) and at University of Oregon Center for Advanced Technology in Education in Eduisland (the latter now relocated). One prim was tailored as a big board, on which the instructor's screen was shared to student visitors (figure 2). As in Skype, both voice communication and instant messaging were available in Second Life and the instructor and the students collaborated solving chemical problems.

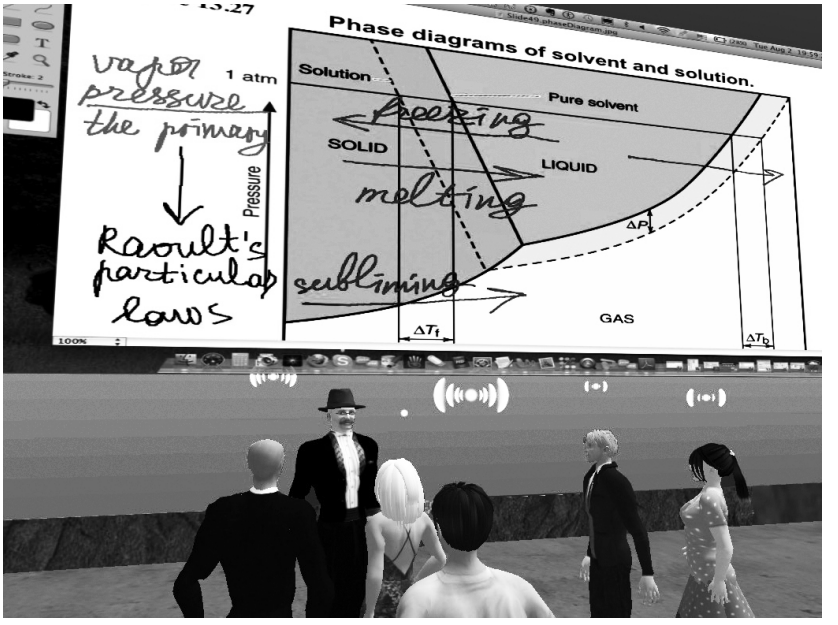

Figure 2: Virtual consultation in Second Life with instructor's screen being shared on the board. The instructor's avatar was created using his real-life photo.

Lecture attendance and screen sharing as well as coming to face-to-face and virtual consultations was optional. Performing homework, quizzes and exams were mandatory.

Other ICT Used

One should mention other software and web resources used, although not in the focus of this research but important for understanding the whole picture:

- iShowU – an application for recording the computer screen and voice(s) around. All the instructor lectures were recorded (screen cast);
- Youtube (http://www.youtube.com/) – a website for storing video. Each lecture screen cast was uploaded to this website after the actual lecture was delivered in the auditorium;
- Blackboard (https://blackboard.uoregon.edu/) – a course management system adopted at University of Oregon. The instructor, the teaching assistants, and the students used it for everyday academic orientation. The join.me access codes, links to the lecture screen casts as well as current quiz and exam grades were posted there;
- Connect (http://connect.mcgraw-hill.com) and WebAssign (http://www.webassign.net/) – homework management systems coupled with the course textbook (Silberberg, 2011). Student used it to complete and submit their homework.

Instrument and Procedure

After the course was over (2011 and 2012), the students were asked to respond a 14-item questionnaire (Slabin, 2011) mounted on Qualtrics, a platform for online data collection (table 2).

Questions 2, 5, 8 aimed at studying students' opinions about the idea of screen sharing, and questions 3, 6, 9 aimed at studying students' opinions about the implementation of screen sharing in the given course of General Chemistry. To gain ordinal data, each item implied a response on a 4-point Likert scale ranging from 1 ("Bad") to 4 ("Good") to produce an ipsative measure with no indifferent option available.

Questions 10-14 aimed at collecting additional information about students to identify possible correlations of their opinions with gender, major, residence relative to the campus, employment status, and the final grade for the course.

Questions 1, 4, and 7 did not constitute a scale, and the answers on them were not analyzed. In case a student indicated that s/he had not used screen sharing in join.me at lectures or in Skype at consultations, s/he was not given the two subsequent questions regarding his/her opinion about the idea and its implementation, and the questionnaire skipped to the next media.

Table 3. The questionnaire.

No.	Question	Answering Options
1	Lecturing General Chemistry this summer, I shared my computer screen on join.me with students. Did you use this opportunity?	Yes / No
2	What is your general opinion about sharing instructor's screen at chemistry lectures?	Good idea / Fairly good idea / Fairly bad idea / Bad idea
3	How did the lecture screen sharing work?	Good / Fairly good / Fairly bad / Bad
4	I also held daily Skype consultations. Did you use this opportunity?	Yes / No
5	What is your general opinion about sharing instructor's screen in Skype consultations in chemistry?	Good idea / Fairly good idea / Fairly bad idea / Bad idea
6	How did the consultation screen sharing in Skype work?	Good / Fairly good / Fairly bad / Bad
7	I also held daily consultations in Second Life. Did you use this opportunity?	Yes / No
8	What is your general opinion about sharing instructor's screen in Second Life consultations in chemistry?	Good idea / Fairly good idea / Fairly bad idea / Bad idea
9	How did the consultation screen sharing in Second Life work?	Good / Fairly good / Fairly bad / Bad
10	Please share some personal info. What is your gender?	Male / Female
11	While taking this course, where did you reside?	Campus city / 10 miles from the campus city / Farther
12	What is (will be) your major?	Science / Non-Science / Undeclared
13	While taking this course, were you also working?	Yes / No
14	What grade did you get for this course?	A / B / C / D

Students also expressed their opinions in the text boxes provided in the questionnaire as well as in regular course evaluations routinely conducted by the university.

In each of the two consecutive years, the link to the questionnaire was sent out in email to students during the final week of the course, after they had received their grades. The students had one week to respond the questionnaire.

Data Analysis

The data analysis in this study involved descriptive statistics treating all the responses together as a whole and breaking down the same statistics into student categories (females vs. males, science vs. non-science major, working vs. not working, residing in the campus city vs. residing off the campus city). Mean, mode, median, and inter-quartile range were calculated for each group to aid in their comparison.

To evaluate significance in difference of students' opinions in respect to the above characteristics, the data were run through non-parametric Mann-Whitney U-test. The raw data were ranked, and the

calculated U-statistics was juxtaposed with the critical values for the Mann-Whitney U distribution.

To evaluate differences in students' opinions in respect to students' grades, non-parametric Wilcoxon signed rank test was used.

Results of the Research

The questionnaire indicated that 17% (17 of 36) students were females; 67% (24 of 36) students lived in the campus city, 25% (9) within ten miles from it and 8.3% (3) farther. 41.7% (15 of 36) were employed. 38.9% (14) students got or expected A (highest), 36% (13) – B, 16.7% (6) – C and 8.3% (3) – D (lowest) grades in the General Chemistry course.

Most students used all the three media to watch the instructor's screen shared at least one time. Screen sharing via Skype and Second Life turned out to be widely popular among students (94.4% or 34 of 36 and 83.3% or 30 of 36, resp.). The results gained through the questionnaire are presented in table 4.

Table 4. Students' opinions about the idea and about the implementation of instructor's screen sharing via various media.

Screen sharing media	Opinion about the idea				Opinion about the implementation			
	Good	Fairly good	Fairly bad	Bad	Good	Fairly good	Fairly bad	Bad
Join.me at lectures*	15	6	-	-	9	11	1	-
	71.43%	28.57%	-	-	42.86%	52.38%	4.76%	
Skype at consultations	20	13	1	-	8	20	5	1
	58.82%	38.24%	2.94%	-	23.53%	58.82%	14.71%	2.94%
Second Life at consultations	17	9	4	-	12	11	5	2
	56.67%	30%	13.33%	-	40%	36.67%	16.67%	6.66%

**The sum in the rows is less than 36 because not all the students tried screen sharing in this specific media.*

Most students welcomed the idea of instructor's screen sharing via join.me, Skype and Second Life. The percentage of "good" and "fairly good" for join.me and Skype was summarily close to 100% each (figure 3, bright columns). On the other hand, 2.9% and 13.3% of the students were sceptical toward the idea of screen sharing in Skype and Second Life, resp. and characterized it as "fairly bad". Along with this, no student characterized the very idea of screen sharing in any media as "bad".

Most students also positively perceived how the instructor's screen sharing had been conducted, being, however, less optimistic (figure 3, dark columns). The percentage of "good" dropped from 71.4% down to 42.9% (join.me at lecture), from 58.8% down to 23.5% (Skype), and from 56.7% to 40% (Second Life). In fact, no student rated the implementation higher than the idea itself; i.e. "fairly good" idea had never related to "good" work – at best it had to "fairly good", sometimes to "fairly bad" or worse. So approving the instructor's screen sharing ideas in principle, the students believed that they could have been applied in a more effective way.

However, while students wowed the instructor's screen sharing practice via join.me, almost 1/4 of them or 23% provided "fairly negative" and "negative" evaluations of screen sharing in Second Life, some even arguing for it being "academically inappropriate".

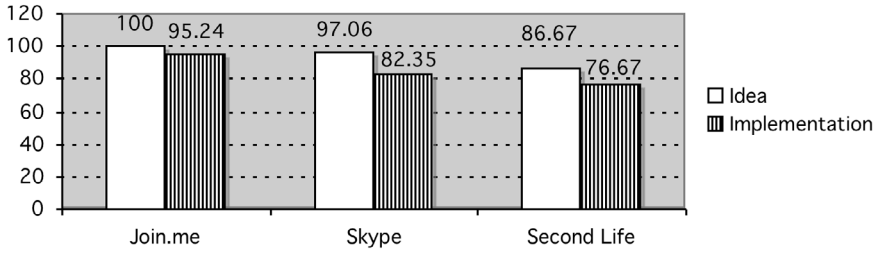

Figure 3: Students' aggregated positive opinions ("Good"+"Fairly good") about the idea (left bright columns) and about the implementation (right dark columns) of the instructor's screen sharing via various media.

Based on students' responses ranging from 1 ("Bad") to 4 ("Good"), median and mode, range and inter-quartile range were calculated to identify the central tendency.

Table 5. Descriptive statistics of male and female students' opinions about the idea of instructor's screen sharing and about its implementation via various media.

Screen sharing media	Median		Mode		Range		Inter-quartile range	
	Male	Female	Male	Female	Male	Female	Male	Female
Join.me, idea	4	4	4	4	1	1	1	0
Skype, idea	4	4	4	4	2	1	1	1
Second Life, idea	3	4	3	4	2	2	1	0
Join.me, implementation	3	3.5	3	4	1	2	1	1
Skype, implementation	3	3	3	3	3	2	1	1
Second Life, implementation	3	3	3,4	4	3	2	1.5	1

Table 6. Descriptive statistics of science and non-science major students' opinions about the idea of instructor's screen sharing and about its implementation via various media.

Screen sharing media	Median		Mode		Range		Inter-quartile range	
	Science	Non-Science*	Science	Non-Science	Science	Non-Science	Science	Non-Science
Join.me, idea	4	4	4	4	1	1	1	0.5
Skype, idea	4	4	4	4	2	1	1	0
Second Life, idea	4	4	4	4	2	1	1	0.5
Join.me, implementation	3	4	3	4	1	1	1	0.5
Skype, implementation	3	3	3	3	3	2	1	0
Second Life, implementation	3	4	4	4	3	1	2	1

**Undeclared major and community education program students were excluded from calculation.*

Table 7. Descriptive statistics of working and non-working students' opinions about the idea of instructor's screen sharing and about its implementation via various media.

Screen sharing media	Median		Mode		Range		Inter-quartile range	
	Working	Non-Working	Working	Non-Working	Working	Non-Working	Working	Non-Working
Join.me, idea	4	4	4	4	1	1	0.5	1
Skype, idea	4	4	4	4	2	1	1	1
Second Life, idea	3	4	4	4	2	1	2	1
Join.me, implementation	3	4	3,4	4	2	1	1	1
Skype, implementation	3	3	3	3	3	2	1.5	0
Second Life, implementation	3	3	4	3	3	1	2	1

Table 8. Descriptive statistics of campus and off-campus city resident students' opinions about the idea and about the implementation of instructor's screen sharing via various media.

Screen sharing media	Median		Mode		Range		Inter-quartile range	
	Campus	Off-Campus*	Campus	Off-Campus	Campus	Off-Campus	Campus	Off-Campus
Jan. me, idea	4	4	4	4	1	1	0.5	1
Skype, idea	4	3	4	3	1	2	1	1
Second Life, idea	4	4	4	4	2	2	1	1
Join.me, implementation	3	4	3	4	2	1	1	1
Skype, implementation	3	3	3	3	2	3	0.5	1
Second Life, implementation	3	4	3	4	3	2	1.5	1

**Students living within ten miles from the campus and farther were put in the same off-campus category.*

Median values 4 ("Good") and 3 ("Fairly good") in the above tables indicate the central tendency to positive evaluation of instructor's screen sharing in the present student categories.

Table 8. The mean of students' opinions and Mann-Whitney U-statistic values in respect to student gender, major, residence, and employment.

Screen sharing media		Gender		Major		Residence		Employment	
		M	F	Science	Non-science	Campus city	Off-campus	Working	Not working
Join.me, idea	Mean	3.56	3.83	3.69	3.75	3.75	3.67	3.78	3.67
	U	39		27.5		49.5		60	
Skype, idea	Mean	3.47	3.65	3.52	3.83	3.67	3.30	3.54	3.57
	U	124.5		96		84		138	

Screen sharing media		Gender		Major		Residence		Employment	
		M	F	Science	Non-science	Campus city	Off-campus	Working	Not working
Second Life, idea	Mean	3.19	3.71	3.36	3.80	3.45	3.40	3.14	3.69
	U	157.5		71		100		73	
Join.me, implementation	Mean	3.33	3.42	3.38	3.75	3.25	3.56	3.33	3.42
	U	48		18.5		68		52	
Skype, implementation	Mean	3.18	2.88	3.08	3.00	3.13	2.80	3.00	3.03
		182		68		97.5		139	
Second Life, implementation	Mean	3.00	2.21	2.95	3.60	2.95	3.40	2.86	3.31
	U	122		75		128		91	

Because U-statistic values fall into the corresponding critical intervals, the results show no significant difference in all the present student categories but gender in case of screen sharing in Second Life idea (U=157.5 at critical interval 71–153 and $p < 0.05$). According to this, female students provided significantly more positive opinions about the idea of screen sharing in Second Life than male students.

Table 9. The results of Wilcoxon signed rank test in respect to students' final grades.

Screen sharing media	Sample size	Signed ranks	z-ratio	W	Critical value of W at .05
Join.me, idea	21	16	2.88	112	58
Skype, idea	30	26	2.37	187	137
Second Life, idea	34	20	1.37	74	182
Join.me, implementation	21	15	2.03	72	58
Skype, implementation	30	22	0.15	10	137
Second Life, implementation	34	23	0.02	137	182

The test showed significant differences in students' grades when they provided their opinions about the idea and practice of instructor's screen sharing in Second Life ($W=74 < 182$ and $W=137 < 182$, resp. at $p<0.05$) and about the practice of screen sharing in Skype ($W=10 < 137$ at $p<0.05$). According to this, students with higher grades provided more positive opinions about. The rest did not show significant differences in grades regarding other media.

In oral statements, students expressed their opinions about effectiveness of virtual consultations and screen sharing for specific general chemistry topics. In general, consultations were effective when the material could be covered in one computer screen (e.g. naming a compound, writing some formulas, some simple chemical equations or one voluminous equation, a one-two-step solved problem, an atomic configuration). When the task required two or more screens for explanation (e.g. derivation of kinetics and thermodynamics formulas, solving a multistep problem), the instructor had to clear some handwritten area to free the screen for next explanations, and thus the effectiveness of consultation decreased.

The students also expressed their opinions in the text boxes provided in the questionnaire and in the routine university evaluations about:

- the lecture join.me screen sharing: "*I wish every teacher did it!*", "*Loved it! So useful!*", "*Fantastic, helped immensely*";
- the Skype screen sharing: "*It allows students with a busy schedule to ask questions outside of class and office hours!*", "*More accessibility to help!*", "*Very accessible*", even "*It was extremely helpful and easier to access than office hours face to face*";

- the Second Life screen sharing: "*Amazing*", "*Very helpful when working on my homework to ask for help*", "*Good, just not for me*", "*It might be more frustrating to some students to have to handle SL and the class. However for an extra office hours opportunity it seems worth it*", "*Runs slowly on many computers, otherwise good idea*", "*Too distracting for me when I was stressed about the chemistry problems*", "*Second Life is a deep and dark corner of the Internet that has no place in academics. It's a cool idea but the platform is so sinister, corrupt, and vulnerable to abuse that it's not worth it.*"

More student feedback included opinions about:

- instructor handwriting on the slides using Bamboo tablet: "*When the instructor did examples I liked how he wrote out all of his work. It made it easier to follow*", "*I enjoy the way you write on the slides, and how many slides you have, but sometimes it is hard to understand your writing*");
- recording lecture screen casts and uploading them to Youtube ("*JoinMe was great, all the extra things you did besides just lecture was very helpful. I loved being able to go home, start the homework then be able to pull up the lecture of that day's class and re-watch it to get a better understanding*", "*Having homework Monday-Thursday, I am able to apply what I learned that day in lecture to what the homework is on*", "*Clear presentation quality uses lots of resources, the screen casts were nice*", "*I had a tutor, used the books, and re-watched online lectures. This helped me immensely*", "*Fantastic idea, I was able to go home after lecture and re-watch if I needed too*", "*Sometimes when I missed the class, it is a important way*", "*Gives people who really had to miss class a chance to catch up.*"

Discussion

The research showed that most students had positive opinions about the idea and practice of instructor's screen sharing at lectures and consultations on General Chemistry. One should consider this fact in light of screen sharing being a case of online collaborative learning, which in turn is a computer-mediated version of the traditional in-class collaborative learning. The students in the research were involved into it, especially during collective consultations in Second Life, working as a learning team with collaborations "instructor–student" and "student–student". The encouragement of active learning, deep processing of information, critical thinking are believed to remain valid in online collaborative learning environments, just as they do in traditional collaborative settings (Graham, 2004).

The students' positive opinions may reflect their personal satisfaction, regarding the recent study of student teamwork satisfaction and their attitudes toward online collaborative learning (Ku, Tseng, Akarasriworn, 2013). These authors found that the student attitude has moderate to high degrees of correlation with teamwork satisfaction. They identified critical elements of successful online collaborative settings including instructor support and encouragement, clear objectives and goals, clear communication, use of interactive software, synchronous meetings, and well-defined and well-organized instruction.

Students' predominantly positive opinions about screen sharing can be due to growing familiarity with communicating online and using social networks, although it does not seem to influence the online learning (Bennett, Bishop, Dalgarno, Waycott, Kennedy, 2012).

Instructor's screen sharing in Second Life received the least positive (most negative) students' opinions that can be explained by many factors. A number of sources of negative emotions that can arise when group work is mediated by technology were described (Robinson, 2013), among them are technical breakdowns and disruption to online services. In the current study, there were a number of technical issues. The faster the instructor writes, the more frequently the image on student screen must be refreshed to ensure continual perception. However, transfer of graphical information from instructor to student screen did not happen instantly that, depending on the modem, computer and the whole communication line characteristics, caused delays and misunderstanding. Often the instructor and the students were literally not on the same page. Tolerable in auditorium where the projected screen was available as a backup, this fact frustrated students where the screen was the only. Sometimes for screen sharing during Skype consultations the instructor and the students had to change for join.me, leaving

Skype just for voice communication. Such changes were far more common in screen sharing during consultations in Second Life.

Other identified issues (Robinson, 2013) include alongside problems from the way the online learning space has been designed, difficulties with interpreting and following instructions, frustration and fear when using online technologies, a lack of information about peer students and a lack of means for self-expression in virtual environment. Lack of communication and online trust resulting in low group cohesion (Tseng, Yeh, 2012) could also contribute to students' negative opinions. In the current study, at consultations in Second Life students and instructor communicated as avatars limited in facial expression and other non-verbal cues. The students were sometimes preoccupied by problems navigating inworld, their avatar appearance, and presence of other avatars. Typically, the students were not familiar with each other before the course and at virtual collective consultations had to communicate with disembodied peers whom they had never met.

Besides, student' modest evaluation of screen sharing could result from specifics of chemistry. To understand chemical concepts, often 3D space is necessary for explanation, and in face-to-face communication it is easily done by demonstrating, e.g. crystal lattice or ball-and-stick models. In the current study, the screen sharing actually remained 2D even in called 3D Second Life. As a result, understanding is up to student's spatial imagination, and the 3D environments facilitate it but cannot replace it.

The statistically significant finding that students with higher grades provided more positive opinions about the practice of screen sharing in Skype and Second Life can also be explained by the mentioned (Ku, Tseng, Akarasriworn, 2013) correlation between satisfaction (higher grade) and personal attitude.

The results also revealed that female students had more positive opinions about the idea of instructor's screen sharing in Second Life. This confirms the research hypothesis about the difference in male and female students' opinions, especially about multi-user 3D virtual environments. It is in concert with the recent study that argued that although the disparities between female and male behavior in 3D virtual environments is more attributed to gaming status rather than gender, college-aged women are more likely to be "non-gamers" and men are more likely to be "gamers" in classrooms, and there appear to be general differences in conceptions of identity, beliefs of the nature of the multi-user virtual environments, and technical skill (DeNoyelles & Seo, 2011). Male and female college students perceive Web 2.0 applications differently when considering them for learning tasks (Huang, Hood, Yoo, 2012). The finding in the current study can also be interpreted within the concept of collaborative learning. It was stated "women are more likely to collaborate, possibly arising out of sex differences in desire to collaborate" (Hunter & Leahey, 2008).

Conclusions

The research showed that most students have positive opinions about the idea and the implementation of instructor's screen sharing via website join.me, Skype, and Second Life for teaching General Chemistry. These opinions are products of many factors, of which the most important are technical and psychological. Collaborative learning theory can help to understand students' perception of instructor's screen sharing. In turn, the involved sharing media (websites, VoIP applications and multi-user 3D virtual environments) can be used to develop a framework for collaborative learning.

Although Second Life objectively provides more educational affordances than any media, students' opinions about it turned out least positive that requires further investigation in this area. Another recommendation that arises from this study is to include screen sharing to develop friendlier chemistry online courses, tutoring strategies, and educational 3D worlds with more intuitive navigation.

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