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A Comparison of Rural Elementary School Teacher Attitudes Toward Three Modes of Distance Education for Science Professional Development

Leonard Annetta · James A. Shymansky

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Abstract Distance education is a significant topic of discussion among faculty at all levels of education. This study produced evidence regarding the attitudes toward three distance education delivery modes for science professional development. The study involved 94 elementary school teachers who were participating in a professional development project. The three distance education strategies studied were live, interactive television (Live); videotape presentations with live wrap-around discussions (Video); and asynchronous, Web-based sessions with streamed video presentations supported by interaction through discussion boards (Web). A repeated measures design was used to analyze the attitudes of the study participants. Data on the participants' attitudes toward their distance education involvement were collected through the CTLSilhouette™ instrument.

Introduction and Purpose of the Study

In 1998, a United States Department of Education study suggested that well over 70% of institutions of higher education would provide distance education courses by 2003 (Lewis, Snow, Farris, and Levin 1999). The same study stated that an estimated 1,680 institutions were already offering more than 54,000 distance education courses. Lewis et al. also reported that an estimated 70 million adult learners were involved in some form of continuing education. It has been estimated that 2.6 million students enrolled in distance education courses in the fall of 2004, an increase of nearly 25% from 2003 (The Sloan Consortium 2004).

L. Annetta (✉)
College of Education, North Carolina State University, Raleigh, NC 27695-7801, USA
e-mail: len_annetta@ncsu.edu

J. A. Shymansky
College of Education, University of Missouri, St. Louis, MO 63121-4400, USA

Distance education has become a very popular avenue for fulfilling course requirements or professional development for teachers. The most commonly cited benefit of distance education is the time flexibility it brings to the end user. However, this and other studies are needed to determine if the aforementioned avenues foster positive attitudes toward professional development from a distance.

The purpose of this study was to compare participant attitudes toward three different delivery modes used for their science teaching professional development: (a) Interactive television, identified as Live mode in this study, is a two-way communication medium that allows presenters and students to be at a distance, yet they are able to see and hear each other in real time; (b) Interactive television with live discussions wrapped around videotaped presentations, identified as Video mode, are tape-delayed sessions of a presenter, which are then broadcast over the same channels as interactive television, with a live discussion directed by a facilitator; and asynchronous instruction, identified as Web in this study, is the most commonly used mode of distance education today and allows students to be separated from their instructors by time, space, or both. Specifically, in this study, we sought to answer the question, "Which mode of distance education do practicing elementary school teachers prefer for professional development in science?"

Literature Review

With the growth of the Internet, the current distance education focus has dramatically shifted in the direction of network and Internet-based technologies. Hickman (2003) reported that the Internet is being used more than other continuing education delivery strategies, such as Interactive Television (ITV), correspondence, and live-remote location combinations. The use of distance education continues to increase annually by 40% (Gallagher 2002).

In a comparative study of science learning as a factor of these interventions, Annetta and Shymansky (2006) reported that participants in the Live mode scored higher on content knowledge tests (multiple choice, constructed response, and vignettes) than participants in the Web and Video modes. Participants in the Web mode outperformed participants in the Video mode on multiple choice and constructed response. As current educational reform in the United States demands more qualified teachers, professional development of inservice teachers becomes more critical than ever before. However, the longevity of distance education as a vehicle for professional development highly depends on teacher attitudes toward the delivery strategy.

Science researchers have given much attention to attitudes because of assumed relationships between attitude and many other variables, such as learning and comfort with technology (Koballa 1988). Ajzen and Fishbein (1980) reported that the most important reason for studying attitudes is the relationship of attitude to behavior. Swan (2001) reported that such factors as design clarity, interaction with instructors, and active discussion significantly influenced satisfaction and perceived learning of material. Interaction between instructor and the learner is possibly the most important function of distance learning support (Wheeler 2002).

In a study by Wearmouth, Smith, and Soler (2004), teachers in a professional development computer conferencing course preferred to read a threaded discussion between two or more experts, rather than actively participate in the discussion. However, Newton, Oswald, and Stuart (2002) reported that teachers who have been involved in teacher workshops prior to the distance education component found higher distance course satisfaction, regardless of their age, teaching experience, or prior experience with distance education.

It is no secret that elementary teachers have traditionally had negative attitudes toward science (Skamp 1991; Yates and Goodrum 1990). It is speculated that the negative attitudes about science stem from preservice education programs. Although there is a large body of literature on professional development, there is very little related literature on what or how distance learning could play a role in addressing problems of new standards, accountability, professional development and pedagogy, and content knowledge (Lezberg 1999). With new policy and reform effecting what we teach and how we teach, it is crucial that we explore the best ways in which distance learning technologies can provide professional development before taking the classes to the masses.

Methods

Setting of the Study

A professional development project targeting teachers in rural school districts separated by great distances provided an opportunity to research alternative forms of distance delivery systems. The Science Co-op Project[1] was a National Science Foundation research initiative that focuses on local systemic change in rural school districts in the Midwestern United States. The Science Co-op Project targeted more than 1,300 teachers and more than 20,000 students in 38 school districts spread across approximately 40,000 square miles of land area.

The study took place during the fall of the 3rd year of the Science Co-op Project. In the project, the Live delivery strategy was originally proposed for the distance professional development to take advantage of the established videoconferencing network. The Video delivery strategy emerged in the 2nd year in response to technical problems encountered during the 1st year in trying to connect two distinctly different communication systems across two states and the difficulty experienced in recruiting quality scientists (as presenters) for the 2nd year. The 3rd year of the project incorporated an asynchronous, Web-based (Web) delivery mode due to increased pressure from both the university and videoconferencing network administrations.

The elementary school teachers engaged in the professional development within the project are referred to as the students or study participants. A quasi-experimental

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design, supplemented with follow-up telephone and e-mail conversations with participants, was used to investigate the perceived effectiveness of the three distance-learning strategies for science professional development.

The data collection process unfolded in two phases. Phase I of the research involved recruitment of the participants and the assessment of their prior science knowledge, predisposition to constructivist teaching methods, and technology self-efficacy. Phase I was accomplished during the 40-hour summer workshop in June 2002. The results of the prior knowledge test and the participant predisposition to constructivist teaching provided an even bell curve that allowed participants to be stratified across three modes of Live, Video, and Web communication modes. The 94 participants were stratified with high, middle, and low achievers distributed across each of the three modes. Special care was taken to stratify those participants who had already been exposed to one of the three modes across the other modes. Phase II consisted of the intervention and data collection, which was conducted over a 12-week period.

Study Variables

The independent variable of this study was the distance education delivery mode: (a) live, two-way audio and video (Live); (b) videotape with wrap-around discussion (Video); and (c) Web-based, asynchronous sessions (Web). The dependent variable was attitudes toward delivery modes. The following describes the science expert presenters, the delivery modes, and the presentation and discussion format.

Presenters of the distance education sessions were scientists from three research universities, one biotechnology research company, and master teachers from local school systems. They were coached on the presentation and discussion formats with information about the project goals and the audience's limited science background. Student misconceptions were gathered from the teachers in the study well in advance of the actual presentations. These misconceptions were brought to the attention of the science expert presenters prior to their session. The misconceptions also became part of the postsession survey each participant completed.

The Delivery Modes

The Live sessions were conducted from an origination site from which the science expert presenter and the session facilitator broadcast and up to eight remote sites from which the teachers participated. At the remote sites, teachers met in small groups in media rooms within their school district. These rooms contained television monitors on which they could see and hear in real time the speaker and the teacher groups at the other sites. A camera mounted on the back wall of the room at the origination site captured the science expert presenter and a camera mounted on the front wall at each of the remote sites moved automatically to the teacher participant who was speaking. Audio was captured through microphones at the science expert podium and at the teacher desks controlled by a single button that allowed the audio

to be muted during small-group discussion. The Live sessions followed a structure of an approximately 30-minute science expert presentation, followed by 10 minutes of on-site collaboration of teachers in small groups to generate specific questions for the science expert presenter. After circulating through each site and allowing for the science expert presenter to respond to particular questions, the small groups again met for 10 minutes to share ideas for incorporating the new knowledge into their classroom practice. These ideas were finally shared with the entire group involved in that session. The sessions were didactic in nature and never imparted any hands-on activities to the teachers. The participants had one week to complete and submit a postsession online survey.

The videotapes, used in the Video mode, were taken from the Live 30-minute presentations that were broadcast the previous week. The Video sessions were aired on the same network over which the Live sessions were broadcast. As in the Live sessions, there was an origination site from which the videotape was played by a session host and, again, as many as eight remote sites were involved for any given session. At the remote sites, teachers met in small groups in media rooms within their rural school district and had a facilitator in the room to gather questions and facilitate discussion. Within these sessions, the teachers viewed a presentation were then led through a discussion with the other sites about what types of questions they would have from the presentation and how they might be able to integrate what they learned into their classrooms. Finally, the teachers viewed the discussion section videotaped during the previous week's Live presentation and reformulated a list of questions, because some of their own questions were often common to what they viewed on the videotape. Specific questions were e-mailed to the science expert presenter or posted on the project website. Answers to the questions were again posted on the Web site and e-mailed to all participants who had participated in that Video session. The participants had one week to complete and submit a postsession online survey.

The Web component was distinctly different from the previous two modes in a number of ways. The fundamental notion of asynchronous communication is that it disregards time and place. Participants were flexible in terms of when and where they engaged in these sessions. Rather than viewing a live science expert presenter or videotape of a presentation, participants in this mode viewed a streamed video of the Live presentation. This was accomplished by digitizing the videotape of the original Live session in Macintosh Imovie.® The teachers interacted with each other through a discussion board within the framework of the Blackboard® course-management system. The participants had 1 week to view the streamed video and interact in the discussion room. These participants had a 2nd week to complete the postsession online survey.

Research Design and Sample

Teachers participating in the 3rd year of the project were randomly assigned to one of the three distance delivery modes in which they selected at least four science

Table 1 Participant breakout per topic and mode of delivery

	Topic 1 (Biotech-nology)	Topic 2 (Space science)	Topic 3 (Population variation)	Topic 4 (Simple machines)	Topic 5 (Rocks & fossils)	Topic 6 (Weather)
Live (31 participants)	6	30	16	31	30	27
Video (32 participants)	6	26	15	25	32	30
Web (31 participants)	6	26	14	27	29	28

topics from the six topics offered. The topics offered and the number of participants involved in those topics in their respective delivery mode is represented in Table 1.

As each teacher participated in the succession of four or more topics within their assigned delivery mode, the measurement of the dependent variable (attitude toward delivery mode) was repeated. Participants included 7 males and 87 females. Teaching experience ranged from novice (32% taught for 5 years or less) to more seasoned (21.5% taught 20 or more years). However, most of the participants were in their first 10 years of teaching (56%). There was a substantial number of participants (74%) with little or no formal science education coursework on their college transcripts. Of the teachers in the study, 8% specialized in science or secondary science education, and 19.4% reported that they had some distance education experience in the Live mode.

Instrumentation

Washington State University developed an online data collection tool known as CTLSilhouette,[2] which is the software that carries the Flashlight Online[3] service. The instrument used in this study was a modification of CTLSilhouette and was designed to ascertain the teacher participants' attitudes about the effectiveness of the mode of distance delivery for the science professional development in which they participated. This online instrument allows for anonymity and easy conversion to the statistical software used for analysis. Each participant in the study was assigned a unique login ID to ensure anonymity. The instrument probed individual attitudes toward the different components of their respective modes, using a four-point Likert-type format (with a "Not applicable" as a fifth choice; see Appendix).

Reliability scores from the CTLSilhouette instrument were determined through double-blind ratings. The items in the database were greater than 90% reliable. The participants also completed a survey after each session to share data on their attitudes toward the technology and the perceived effectiveness of the professional development session.[4]

[2] http://www.ctlt.wsu.edu/CTLSilhouetteinfo.asp

[3] http://flashlightonline.wsu.edu/

[4] This survey can be obtained from the authors.

Data Analysis

Responses to items on the postsession survey were subjected to a maximum likelihood factor analysis to identify the major scales within the data set. The extracted factors were subjected to varimax rotation, which maximized the variance of loadings within each factor. Results of the varimax rotation yielded the following factors:

Factor 1: My knowledge was enhanced.

Factor 2: Effective interactions occurred.

Factor 3: Technical difficulties hampered my learning.

Factor 4: The session built confidence in my science knowledge.

Each factor was transformed into a z score (-1–$+1$) and treated as a dependent variable in a mixed-model analysis of variance (ANOVA), which was used to test the null hypothesis of no difference in attitudes toward learning science among teachers who participated in Live, Video, and Web instruction. Factors of mode of distance education and science background, represented by semester hours of science content taken during the Bachelor's, Master's or beyond-Master's level, were fixed; t tests were used to examine differences in the means for effects of the fixed factors, mode, and science content experience on Factors 1–4.

Results

Factor analysis performed on the attitudinal scales from the postsession surveys provided evidence that at least three, but not more than four, factors are present in the battery of attitude items. Table 2 provides the significance test run on 366 observations.

In the primary analysis, each factor score (expressed as z scores) was treated as the dependent (response) variable in a mixed-model analysis with fixed factors mode and teaching experience and with subject ID as a random factor. There was a significant difference in z scores for Factor 2 ($p < .001$) as a function of mode of distance delivery. However, the other 3 factors proved statistically nonsignificant: Factor 1 ($p = .17$), Factor 3 ($p = .28$) and Factor 4 ($p = .45$). There were no significant z scores for factors 1, 3, and 4. There were also no significant differences in z scores for any factors as a function of teacher science background.

A follow-up t test on the significant results for Factor 2 showed that teachers rated the Live mode significantly higher in effective interactions than both the Video and Web modes and the Video mode significantly higher than the Web mode as well (see Table 3).

Table 2 Chi-square test for significance of attitudinal factors

Test	*df*	X^2	Probability
H_0: 4 Factors are sufficient	24	34.7097	>.0728

Table 3 Difference in least squares means on mode effect on perceived effectiveness of interactions

Mode contrast	Mean contrast	Error	*df*	*t*	Probability	Lower	Upper
Live versus Video	0.84	.17	92.4	5.04	<.0001	0.51	1.18
Live versus Web	1.64	.17	62.8	9.51	<.0001	1.30	2.00
Video versus Web	0.8	.18	64.4	4.44	<.0001	0.44	1.15

Discussion

Mode of delivery had a significant influence on Factor 2, effective interaction occurred. Sherry (1996) argued that successful distance education should not be an independent and isolated form of learning. On the other hand, Franklin, Yoakam, and Warren (1996) contended that introverted students who are too shy or lack the self-confidence to participate in the traditional classroom setting will potentially open up when provided the opportunity to interact via e-mail or in chat rooms. So, which perspective is most defensible, based on the results of this study?

The Live group perceived much greater interaction than the Video and Web groups (see Fig. 1). If one accepts that oral communication is innately the most effective form of communication, live, collaborative interaction among learners will result in a sense of community that recognizes individual needs, strengths, peer support, and cognitive synergy (Cooper and Mueck 1990). In the Live and Video sessions, the participants had the opportunity to be part of a first-hand support group. The small-group, on-site discussions provided a chance for those who understood the presentation to share their insights with others in the group. Consequently, this gave the shy or the student who did not understand the material the opportunity to observe and ask questions of others at their own site without having to interact with the entire population.

The Web group had the least effective communication, as nonverbal communication through typing was the only avenue to communicate with others involved in the session. Asynchronous learning allows for more time flexibility, but this flexibility comes at a price. A deep, meaningful discussion online requires exceptional typing and grammatical skills to communicate effectively, and this is too time intensive for most people. This was seen as a major deterrent in the Web mode. The Web group spent an average of almost 11 hours online watching the streamed video and working in the discussion board, compared to the 2 hours that participants in the Live and Video groups spent on a given topic.

The time delay in posted threads may not have given the participants the feeling that they were truly interacting. Perhaps it would have been more efficient if there had been a set time for a chat room, rather than asynchronous discussion. Perhaps a voice-simulated discussion board that transforms voice messages to text is the next technology that needs to be developed if Web instruction is to be the delivery mode of choice. Those who are not proficient at typing or those who would rather not type would then be able to express their thoughts and ideas orally, and others could see their work as written text. With the onset of higher bandwidth Internet connections, the possibility for web conferencing could add another possibility for rich,

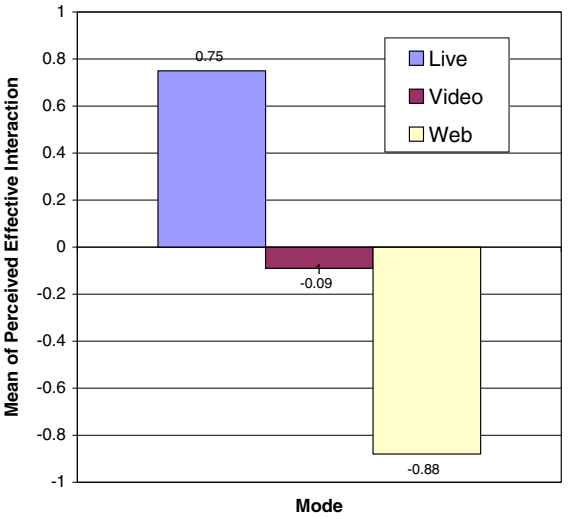

Fig. 1 Mode effect on the perception of effectiveness of interaction

interactive synchronous instruction. Simply put, interaction between students and content is a critical component of learning—whether the instruction is campus-based or over distance education channels (Anderson 2002).

In the teaching profession, where a lack of enough time is always the enemy, it is difficult to feel you are getting enough substance from a course when you are spending the majority of your time reading, typing, re-reading and re-typing. This is the essence of an online discussion, yet students in an asynchronous environment never received the cognitive closure that would have completed their learning.

In the book *Web-Teaching*, Brooks (1997) predicted that students who are poor at self-regulation easily can be "slaughtered" in the WWW-based courses (p. 135). Mode of delivery did not significantly influence Factor 3 (perceived technical difficulties). This is noteworthy, since the use of technology invariably produces some difficulty for the user. Although some of the participants expressed difficulty hearing the science expert presenter and seeing the multimedia in all three modes, the majority did not find this to be a major deterrent on their professional development experience. These technical difficulties were minor and were easily circumvented by the science expert presenter's e-mailing the notes, PowerPoint presentations, and so forth to the participants if participants expressed any problems seeing the presentation. This actually became a trend, as the participants asked for this information prior to each session so they would not have to endure not seeing the graphics during the sessions. It also allowed the participants to feel that they did not need to take copious notes during the sessions. Although the PowerPoint™ presentation was not provided before the session, invariably the participants received all of the information they requested after the session.

Mode of delivery did not have a significant influence on Factor 4 (session built confidence in my science knowledge). Although it was assumed that elementary school teachers have traditionally held negative attitudes toward science (Skamp 1991; Yates and Goodrum 1990) due, in part, to a lack of content knowledge, most teachers expressed confidence about their science knowledge. An explanation for this

might be that some of the participants were in their 3rd year of this professional development project, and they had gained significant science knowledge and confidence in their science teaching during that time. Furthermore, it was made very clear to each science expert presenter prior to their session that the audience generally lacked a strong science background and that the presentation should be prepared with that in mind. Since each of the three groups viewed the same presentation, it is no surprise that there was not a significant difference between the modes.

Implications for Practice

The results of this study provide answers to questions not addressed by those who have advocated for the departure of brick-and-mortar education and the arrival of cyber-based education. Although this study sheds light on elementary school teacher attitudes toward distance education for science professional development, the reality is that the adult participants in this study represent the age bracket of students who are enrolling in most postsecondary institutions today.

There is a need to reach the masses for the purposes of professional development, and using distance education technologies just might be the vehicle. The results of a study released by Horizon Research (Fulp 2002) reported that almost three quarters of the science teachers in grades K–5 had 15 or fewer hours of science coursework. More than 75% of the sample reported a need for professional development to deepen their own science knowledge. Professional development that focuses on specific content—and how students can learn that content—provides opportunity for active learning and that is integrated into the teachers' daily practices is more likely to produce enhanced knowledge and skills and, thus, will have a greater positive effect on student achievement outcomes (Garet, Porter, Desimone, Birman, and Suk Yoon 2001). This is especially true for those in underserved, rural areas who are traditionally isolated from quality professional growth (Renyi 1996; Williams et al. 1995).

Quality instruction in distance education, however, is another critical aspect of successful distance education. Too often instructors are not trained in effective use of the technologies available; and, thus, they do not design their lessons to take advantage of these technologies. In this study, it was deemed pertinent not to train the instructors so the results would be generalizable to the field. But teaching via distance technology is extremely time intensive if done properly. It would, therefore, not be unreasonable to suggest that each distance education course be considered a greater load (e.g., one and one-half courses) than that allocated for a traditional course.

As Svetcov (2000) noted, we are at the beginning of some very exciting times. Schank (1994), a computer scientist at Northwestern University who runs an online learning service, perhaps summed up the future of distance education best:

> We are witnessing the dawn of a new era in education. In the beginning it will look a lot like what it is replacing, just as early movies were simply filmed plays. But like the movies, online education will evolve into something very different from what now exists. (http://www.cognitivearts.com)

Appendix

Postsession Survey

1. My gender:
   - ☐ Male
   - ☐ Female

2. The highest degree I've earned:
   - ☐ Bachelor's
   - ☐ Bachelor's + 15
   - ☐ Master's/Equivalence
   - ☐ Doctorate

3. My specialization in my BA/BS was:
   - ☐ Elementary Education
   - ☐ Science
   - ☐ Secondary science education
   - ☐ Other

4. I have _____ years of teaching experience.
   - ☐ 0–5
   - ☐ 6–10
   - ☐ 11–15
   - ☐ 16–20
   - ☐ 21–25
   - ☐ 26–30
   - ☐ Over 30

5. Tonight's session was:
   - ☐ Live, 2-way interactive with science expert presenter and other sites
   - ☐ Taped, wrap-around video
   - ☐ Asynchronous, Internet learning

6. Have you ever taken or are you currently taking a course that was asynchronous, Web-based with online discussion with other members?
   - ☐ Yes
   - ☐ No

7. Have you ever taken or are you currently taking a course that was videotaped with 2-way interactive with other members but not the science expert presenter?
   - ☐ Yes
   - ☐ No

8. Have you ever taken or are you currently taking a course that was live, 2-way interactive with the science expert presenter?
   - ☐ Yes
   - ☐ No

Based on your personal experiences in this session, indicate your responses below on the scale from strongly disagree to strongly agree.						
		Strongly disagree	Disagree	Agree	Strongly agree	Not applicable
9.	If there were technical difficulties, the session was negatively impacted.	☐	☐	☐	☐	☐
10.	Your knowledge of science content and/or pedagogy was greatly enhanced in this session.	☐	☐	☐	☐	☐
11.	You have discussed what you learned in this session with other teachers and/or administrators who did NOT participate in the session.	☐	☐	☐	☐	☐
12.	The amount of interaction during the session between science expert presenter and teacher and/or between teacher and teacher was sufficient.	☐	☐	☐	☐	☐
13.	The clarity of the instruction was good.	☐	☐	☐	☐	☐
14.	I feel comfortable asking questions to the science expert presenter.	☐	☐	☐	☐	☐
15.	I find the use of multimedia (PowerPoint, Internet, Video, etc.) to be helpful in learning the science concepts.	☐	☐	☐	☐	☐
16.	I find it difficult to see the monitor clearly.	☐	☐	☐	☐	☐
17.	I frequently find it difficult to hear the science expert presenter and questions asked from other sites.	☐	☐	☐	☐	☐
18.	The content covered in this session is relevant to my work.	☐	☐	☐	☐	☐
19.	Sufficient opportunity was provided for exchange of ideas during the session.	☐	☐	☐	☐	☐
20.	Having participated in this session I now feel more confident to teach a lesson in this content area.	☐	☐	☐	☐	☐

Rank the following in the order of preference. 1 being the highest preference and 4 being the lowest preference.					
I prefer:		1	2	3	4
21.	Live, 2-way interactive with the science expert presenter and others in the session.	☐	☐	☐	☐
22.	Videotaped presentations with wrap-around discussion.	☐	☐	☐	☐
23.	Asynchronous, Web-based sessions.	☐	☐	☐	☐
24.	Face-to-face, traditional sessions.	☐	☐	☐	☐

Rank the following in the order of preference. 1 being the highest preference and 4 being the lowest preference.					
I learn more through:		1	2	3	4
25.	Live, 2-way interactive with the science expert presenter and others in the session.	☐	☐	☐	☐
26.	Videotaped presentations with wrap-around discussion.	☐	☐	☐	☐
27.	Asynchronous, Web-based sessions.	☐	☐	☐	☐
28.	Face-to-face, traditional sessions.	☐	☐	☐	☐

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