

Synchronizing Asynchronous Learning

Combining Synchronous and Asynchronous Techniques

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Abstract—On-line learning uses the terms **synchronous and asynchronous** to describe tools and learning activities. This research looks into the origins of these terms, their use today and asks if these are the correct terms to use and if the use of these terms has held up the development of better tools and techniques.

Keywords—*Asynchronous Learning; Synchronous Learning; Electronic Learning; Web Conference; Videoconferencing; Pedagogy*

I. INTRODUCTION

The term synchronous in everyday use refers to “Existing or happening at the same time ... belonging to the same period” [1]. Asynchronous is defined as “Not synchronous; not existing or occurring at the same time, not coinciding in time...” [2]. The terms originated in medicine and were then adopted in computing: “Of a computer or part of one: not operating in accordance with clock signals; (of operations) beginning when the previous operation finishes, rather than occurring at regular intervals of time...” [2].

II. ORIGIN OF THE TERMS SYNCHRONOUS AND ASYNCHRONOUS

Hrastinski defines synchronous for on-line learning using the examples of videoconferencing and text chat [3]. Asynchronous is defined by reference to e-mail and discussion boards and that asynchronous e-learning does not require teachers and students to be on-line “at the same time” [3]. The definition of synchronous on-line learning would appear to agree with the dictionary definition, being concerned with events happening at the same time. However, the second part of Hrastinski's description of synchronous e-learning, provides a different description: “in real time” [3].

Benbunan-Fich refers to synchronous and asynchronous modes of education being used “... depending on whether the communication is carried out in real time or in delayed time...” and “... real time (synchronous lectures) or delayed time (asynchronous lectures) ...” [4]. Thus the on-line event emulates a traditional classroom, where the teacher and students are at one location, able to speak to each other and share learning materials.

It should be noted that all communication involves a delay in transmission. This delay is not perceptible in a classroom, but can become significant for on-line distance education. Ibrar

reports that for India's satellite based on-line education, the Round Trip Time (RTT) from ground station to satellite and back to the ground can be 250 milliseconds [5]. If the signal needs to be relayed further, such as through a terrestrial wireless network the delay and be several times this and disrupt normal conversation.

While not directly related to latency, Ibrar also describes overcoming limitations in the satellite system by sending large video files in advance of being used for a class [5]. The interactive part of the class is then delivered via a terrestrial low bandwidth network and the locally stored video played as required. Such computer systems are described as “Store and forward”, the term also used for e-mail and bulletin board system (what in on-line learning is referred to as asynchronous).

III. SYNCHRONOUS LEARNING

Much of traditional education is synchronous, in the dictionary meaning of the word: students are provided a timetable of what they need to do and when. Students then synchronism their activities by reference to a calendar and clock, without the need for high speed electronic communications. Also many classroom activities are asynchronous, in that individual students, or groups, are performing different activities at the same time, or the same activities at different times.

Soo explores the concept of “interaction” in on-line distance education, using the Delphi technique with a group of education experts [6]. Eight categories of interaction were identified, being permutations of synchronous/asynchronous, learner/teacher and material/self reflection/learner. The Delphi process found the important educational interactions were Asynchronous: learner – learner(s), teacher – learner and learner – material. The next most important was Synchronous teacher – learner. The least important were Synchronous learner interactions.

Anderson emphasizes the learner centric and social nature of on-line learning [7]. However, their arguing that the on-line environment is a unique cultural context is overstating the case. Academics have used written communication for a culture of scholarship, long before the invention of the Internet.

In defining on-line learning, Anderson highlights the importance of “Interaction”, with the “Educational interactions”

model proposed identifying “Learning to content”, “Learning to teacher”, “learner to learning”, amongst other interactions [7]. However, a simpler model could have just people communicating with each other, via any available media (such as a computer bulletin board, or a book).

Siemens equates three learning terms with epistemological terms:

1. Behaviorism to objectivism: What is produced with education is an observable change in student behavior, as part of objective reality.

2. Cognitivism to Pragmatism: Learning comes from doing practical exercises and thinking about that experience, not just abstract study of concepts.

3. Constructivism and Interpretivism : The learning takes place when the student builds their own internal model of the topic of study [8].

Principles of connectivism are listed, including diversity of opinions, connecting information sources, Capacity to know, continual learning, and decision-making as a learning process. One principle which appears at odds with the others is: "Learning may reside in non-human appliances". Coward reports how investigation of the physiology of the brain provides insights into how the brain works as well as a way to emulate it in software [9]. This may provide new insights which could be applied to education.

Kop and Hill ask if learning theories, and connectivism in particular, meet the needs of learners and will do so in the future [10]. The role of the " learning community" in connectivism is emphasized. The paper goes on to describe "Epistemological Frameworks for Learning" and "Compatibility of Connectivism and Formal Education". The paper concludes by suggesting a "radical discontinuity" due to a flood of new on-line sources of information, which be particularly problematic for schools, which are less Connectivist than higher education. The paper ends by suggesting a "paradigm shift" may be occurring, but does not say what it is.

The flood of new on-line information source's predicted by Kop and Hill has occurred, but without the predicted paradigm shift [10]. The news media on-line sources mimic traditional broadcast and print publications. The limited interactivity provided is similar to the store and forward forums provided in educational software. On-line learning communities use software which supports a similar mode of interaction and appears conventional in format. This may be because on-line educators and tool developers are limited in their thinking by the synchronous/asynchronous dichotomy.

Information diffusion analysis has been applied to investigating how rumors spread through social networks [11]. The same analysis techniques could be applied to on-line student discussion, to identify what roles students (and the tutors) play in information diffusion in the class. This information could be used to identify when information has spread through the class, without t This electronic document is a “live” template and already defines he need for a formal test. The result would be a form of synchronization of the

asynchronous learning process, identifying when the class has reached a level of understanding of a topic, so they can move on to the next.

Dreon and McDonald discuss the use of Quantitative Data Analysis (QDA) for a systematic analysis of the discussions in on-line courses to look at the development of critical thinking skills [12]. However, such analysis has up to now only been a research activity, as it required the manual categorization of audio discussions and sufficient computing power for analysis of large amounts of text chat. With advances in transcription software and processing capacity this could now be done in real time, with the tutor (and perhaps the students) receiving an analysis of the discussion.

IV. COMBINING SYNCHRONOUS AND ASYNCHRONOUS TECHNIQUES

Oliver describes three aspects of what they term "Conventional Teaching": content, activities and implementation [13]. The content is characterized as fixed, linear and structured. The activities are characterized as fragmented, with a lack of context and abstracted. Implementation is said to be teacher as expert, individual learning and discrete assessment.

Oliver contrasts conventional teaching with "Contemporary Teaching", having the inverse characteristics: flexible, unstructured, teacher as coach, outcomes oriented collaborative learning [13]. Oliver was writing from the perspective of 1999. In 2012 post-secondary education, practices have moved toward the contemporary approach envisaged. However, Oliver's view of technology providing flexibility has mixed results. Learning Management (LMS) systems, such as Moodle, reinforce a fixed, linear and structured approach, by offering the course designer only one layout with a list of topics and set dates.

The lack of direct support for real-time learning in the LMS has encouraged a fragmented approach with the class having to switch software packages to move from store-and-forward to real-time mode.

With Oliver's third element "implementation", LMS have had more success, encouraging student discussion forums with the "teacher as coach", facilities for easily creating on-line groups encourages collaborative learning and the ability to easily mark digital artifacts encourages integrated assessment [13].

An example is the use of Moodle at the Australian National University (ANU). The same LMS is used to teach Sanskrit to small groups [14] and engineering to large classes [15]. The Sanskrit class emphasizes individual performance by the student, in small group, with personal involvement of the teacher as coach. The ANU engineering approach is for a more highly structured courses delivered to large classes of engineering students.

A concept of "asynchronous learning within a synchronous framework" is used by the ANU engineering department [15]. While not mentioned by the authors, this approach may have been inspired by engineering practice, which has regular check

points in work, to monitor performance of a system or project. While this project was using "blended" learning (the synchronous components being face-to-face), the same approach should be applied to a pure on-line course which used a combination of synchronous and asynchronous tools.

On-line education theorists have assumed that synchronous learning requires "real-time" communication with no perceptible delays. However, near-real-time communication, with delays of several seconds, may better emulate a classroom situation, be educationally useful and also reduce the resource requirements on computers and networks.

In a face-to-face classroom there is not constant instant communication between all those present. As an example, a teacher does not expect an instant answer to a question from every student simultaneously. Face-to-face teaching practices take into account the asynchronous aspects of the classroom, with repeating important points several times, pausing for effect, summing up, calling for a show of hands and calling for answers, to achieve occasional synchronization.

Cowan compiled estimates of bandwidth used by the Wimba Classroom virtual classroom software product [16]. A typical 40 minute Wimba session with the student watching video required 20kBps and 46.88MB. An interesting aspect of this is the lower bandwidth and total data for pre-recorded sessions (16kBps and 37.5MB). This is because better compression can be used. Just as students can assimilate information better if given more time, so can computers.

What was not mentioned by Cowan was the latency and reliability required for a real-time session [16]. Store and forward systems are less susceptible to communications problems. A relatively simple near-real-time enhancement could be made to store and forward systems, such as Moodle and eliminate the need for completely separate real-time learning package, such as Wimba Classroom.

Real-time learning applications provide emulation of face to face class using audio, video and display of educational materials in real time. These features were available in previous video conferencing systems. Isaacs and Tang reported that a delay of more than one half-second on a video conference disrupted the usual verbal negotiation of turn-taking in a conversation, at which point participants begin to use gestures, such as holding up a hand for attention [17]. The 2012 Follow the Sun on-line conference used formal verbal cues "Over to you now Tony..." [18]. Learning applications have added features to emulate the gesture of a student raising their hand for attention, or to take a poll. These polling functions are used to synchronize the class: the teacher will wait until most students have replied to the poll and then report the results. This is a way to ensure that the focus of the class is on one point.

The new web standard, HTML5, includes provision for synchronizing text, images, audio and other web content. One example is Web Video Timed Text (WebVTT) to synchronize closed captions for the deaf with video [19]. A WebVTT text file contains start and stop times in microseconds for each the text caption. There is no requirement for the video, or the caption file to be transmitted real time, as synchronization is

performed using a clock. HTML5 also includes provision for synchronizing other web content, such as web pages.

LMS, such as Moodle, already have some real time features. All activities by participants are logged with the time from a clock and some activities (such as forums, quizzes and assignments) can have start and end time limits. Moodle's instant messaging facility provides a similar service to text chat in Wimba Classroom. Provided a sufficiently fast Internet connection and Moodle server are used, Moodle can be used for real time learning. Audio and video could be synchronized with the LMS, bridging the gap between synchronous and asynchronous forms of on-line learning.

The combination of synchronous and asynchronous forms of on-line learning could be used to promote a constructivist approach. This could be done by relaxing the current lockstep approach of packages such as Wimba Classroom, where the aim is for all the class to see precisely the same images on screen at precisely the same time. As well as imposing severe limited on the equipment, this also limits the opportunity for the student to build their own internal model by exploring the topic for themselves, as they have to keep up with the live presentation. Relaxing the real time aspect would also the student time for reflection and to be able to explore the materials themselves, within a time limit.

V. CONCLUSION

Current on-line educational literature uses the terms synchronous and asynchronous with meanings different from their use in everyday language and in the computing discipline. It is recommended that these terms be replaced with "real time" and "store and forward", as used in the computing discipline. As well as improving the clarity of discussions of educational theory, this will have practical benefits for the development and use of systems and educational techniques. In particular this can aid the thinking about the development of simpler software for learning support, combining the features of the store-and-forward LMS, with real-time video conferencing. It is recommended the term synchronous be returned to its original meaning and be applied to discussing the coordination of learning activities and the role of synchronization in the learning experience be explored. A further area for research is the use of information diffusion analysis to automatically assess when an on-line class has reached an appropriate level of understanding of a topic and can move on, without the need for an explicit test. New system designs combining what have previously been thought of as separate synchronous and asynchronous forms of on-line learning can then be merged to support a constructivist approach, where each student builds their own understanding in their own time, while also participating in the class to reach common goals.

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