A perspective on Interactive Lecture Demonstrations as a computer supported collaborative learning (CSCL) activity

S. Raj CHAUDHURY, Sarah CANATSEY, Phillip J. WARD

Innovation in Learning Center, University of South Alabama, Mobile, AL 36688, USA

Abstract. Active learning designs that leverage the power of information and computer technologies (ICT) can vary tremendously in how they engage students – individuals, small groups or whole class. Interactive lecture demonstrations (ILDs) are instructor-led activities which engage the whole class and are designed address students’ mental models of core concepts in the discipline. The use of ICT allows for real time experiments conducted using sensors, simulations and even data analysis as the core of the activity. In this perspectives paper, we analyze the features of traditional ILDs through the lens of the field of computer supported collaborative learning (CSCL).

1 Introduction

Active learning environments where technology plays a significant role in mediating interactions between students, the content and the instructor have been the focus of study in the field of Computer Supported Collaborative Learning (CSCL). One lens employed by CSCL researchers to describe technology enhanced active learning environments is through the enactment scripts [1] and the concept of orchestration [2]. In this perspectives paper we describe the elements of a typical physics Interactive Lecture Demonstration (ILD) and its simulation counterpart following the model of Sokoloff and Thornton [3] in terms of a typical script and the orchestration necessary for an effective ILD experience.

2 Interactive Lecture Demonstrations (ILD) scripts

While there is extensive physics education research literature on the underlying conceptual misconceptions that physics ILDs are designed to address, we treat in this paper, the ILD as an active, whole class engagement construct that utilizes computer technologies to rapidly gather and display real world data. The script for an ILD helps instructors design an effective lesson based on a topic that can be demonstrated to the class.

For any given lesson that involves more than straight lecturing, a script or pedagogical pattern specifies: (i) roles and goals of the participants (teacher and students (ii) allocation of materials and tasks (teacher has demo equipment, students have paper and pencil for recording observations) (iii) student grouping (some individual, some group) and learning activities (prediction, discussion, observation, recording, reflection). Once a script has been designed, it must be implemented or enacted.

The most well-known script for ILDs was developed by Sokoloff and Thornton [3]. Sokoloff and Thornton’s script has become a common structure for interactive learning demonstrations. The main parts of the script include – (i) teacher describes the demonstration and does it for the class without ICT measurements, (ii) students are asked to record their initial predictions, (iii) students engage in small group discussion around their individual predictions, (iv) students record final predictions on their “Prediction” sheet (which will be collected), (v) instructor facilitates discussion on predictions, (vi) instructor carries out demonstration using ICT such that data results displayed via projector for the whole class to see, (vii) a few students are
asked to describe the results and they all fill out “Results” sheet (which they keep), and (viii) instructor offers conceptual insight into the phenomenon. Having a clear vision on how to facilitate these steps in order to achieve the learning outcomes desired is an important element of a successful ILD [3].

Crouch and colleagues [4] studied the learning impacts from using ILDs in the classroom. Specifically, they looked at learning impacts between a demonstration without the prediction and demonstrations with the prediction component. The results from that study showed that demonstrations without a prediction component were only as effective as no demonstration at all. This appears to indicate that the prediction step is necessary in this script. The study also examined the effectiveness of the group discussion component in learning. While the results showed a slight increase with the addition of this part of the script, it may not warrant the extra time needed to hold small group discussions during the prediction step if time is an issue. Whereas the prediction step may take only two minutes, the small group discussion could add another 10 minutes to the lesson [4], an important item to consider in how the activity is managed, as described further below.

3 Orchestration within ILDs

Orchestration is a concept that refers to how a teacher manages, in real time, multi-layered activities within the context of the constraints of a real-life teaching scenario [1], [2]. The physics education literature highlights many scenarios where the concept of orchestration would be a useful lens through which to view them – e.g. from Peer Instruction with clickers [5] where the whole class in pairs or small groups interact with instructor posed problems, to Workshop Physics, where traditional lectures are transformed into activity based lessons where small groups of students work with individual sets of laboratory equipment [6].

ILDs sit in a rather unique niche of incorporating active learning lecture techniques with the value of real time responses of physical or simulated laboratory equipment. In this paper we describe the orchestration necessary to successfully carry out ILDs and their accompanying script. The management aspect of orchestration requires multiple coordination efforts which take place during the learning experience. Time management, classroom management, group management, and workflow management are components of an ILD which must be regulated [2]. Specifically, Dimitriades and colleagues mention the following five key aspects that characterize orchestration:

(i) Design and planning – preparation and organization of the learning activities (often performed solely by the teacher, unless pre-reading is required of the students) before their enactment.

(ii) Management and regulation - Coordination that takes place during the enactment of the learning activities: classroom management, time management, group management, equipment management, etc.

(iii) Awareness - the perceptual processes aimed at modelling what is happening in the learning situation, for example, students’ learning progress and actions: this includes teacher self-monitoring, peer awareness, and group awareness.

(iv) Adaptations - the interventions or adaptations to the designed/planned learning activities, to cope with unexpected or extraneous events, take advantage of emergent learning opportunities, or adapt to student learning progress.
Role of the teacher and other actors - the identification of who performs the previous four aspects, and what the relationship is between the actors (e.g. a teacher, an ICT system, students themselves, and any classroom assistants).

As one can see from the list above, orchestration requires the instructor to manage activities which may or may not be part of the learning scenario; activities range from those intrinsic to the script (special attention to misconceptions students might hold for the addressed concepts in physics) to activities which are extrinsic to learning [1]. The latter can be as mundane as allowing sufficient time to distribute and collect response sheets to as complex as maintaining optimal settings for lab equipment.

In the table below, we outline some of the elements of an ILD script (mentioned above) and the orchestration considerations that accompany them.

| Script element | Orchestration consideration |
|----------------|----------------------------|
| 1. Teacher describes the demonstration and does it for the class without ICT measurements | - How long does the description take?  
- What if apparatus ‘fails’; is there assistance to help fix it in time?  
- Does the room layout support all students viewing the demonstration equitably? |
| 2. Students are asked to record individual predictions. | - How long will the teacher give students for the recording?  
- Does the teacher stand at the front of the room or does (s)he walk around? What constitutes all students completing predictions?  
- What will teacher do for students who walk in late, don’t have a pencil etc.? |
| 3. Class engages in small group discussions with nearest neighbors. | - How long does the class engage in discussion?  
- What is an optimal group size? Is the room layout conducive to such conversation?  
- How does the teacher handle students who are introverts and sit by themselves? |
| 4. Each student records final prediction on “Prediction” sheet (which is collected). | - How long does the teacher give students for this task?  
- Who collects the sheets? How does one ensure that all sheets are collected? |

All eight steps in the ILD script are not listed here, but hopefully what has been presented highlight the general nature of orchestration considerations. While many of these are unconsciously undertaken by any experienced teacher, whenever one engages in a new form of active learning, the value of both the script and the orchestration become apparent. Expert teachers improve their orchestration to elicit maximum performance from students and produce improved learning outcomes.
4 Orchestration for an online ILD

With the growth of synchronous and asynchronous online learning, it is important to adapt traditional pedagogies and activities to the virtual world. While the traditional eight-step ILD script in physics addresses demonstrations carried out with laboratory equipment such as low friction carts, motion probes and air tracks, the source of the ILD can be modeling or simulation based. The Moving Man simulation from the PhET collection [7] forms the basis for our adaptation of the traditional ILD script to online learning – e.g. a synchronous lecture hosted on a web conferencing system such as Zoom or WebEx. This simulation addresses basic concepts in one dimensional kinematics and helps students link visual and graphical representations of motion.

The activity sheets used for a demonstration of the Moving Man ILD are presented below. As part of the preparation for the ILD, the initial settings of the software in order to obtain reasonable results within a short time frame were: initial position: +5.0 meters; initial velocity: -2.4 meters/second; initial acceleration: +0.4 meters/second$^2$. The ability to hide the position, velocity and acceleration graphs while showing the students what the motion of the man looks like when subjected to the chosen physical parameters is a powerful way to connect multiple representations – a principle at the heart of this technique.

![Figure 1: Prediction sheet for Moving Man sim](image)
5 Conclusions

We offer a fresh perspective on a mature active learning strategy, the Interactive Lecture Demonstration (ILD), that is widely accepted as effective within the physics education community. We do so by viewing the ILD through the lens of scripts and orchestration from the field of computer supported collaborative learning. The script of a traditional ILD is mapped out along with considerations for enacting it effectively (orchestration). We give consideration to the growth of online learning and a need to adapt traditional active learning methods to this new medium by designing an ILD using a simulation which addresses concepts in kinematics.

References

[1] Dillenbourg P, Jermann P (2007) Designing Integrative Scripts. In: Fischer F, Kollar I, Mandl H, Haake J M (eds) Scripting Computer-Supported Collaborative Learning. Computer-Supported Collaborative Learning, vol. 6, Springer, Boston, MA
[2] Dimitriadis, Y, Prieto, L P and Asensio-Pérez, J I (2013) The role of design and enactment patterns in orchestration: Helping to integrate technology in blended classroom ecosystems. Computers and Education, 69496-499.
[3] Sokoloff, D R, and Thornton, R K (1997) Using Interactive Lecture Demonstrations to Create an Active Learning Environment. The Physics Teacher, 35 340.
[4] Couch C, Fagen A P, Callan J P, & Mazur, E (2004) Classroom demonstrations: Learning tools or entertainment? American Journal of Physics, 72 (6). 835-838.
[5] Mazur E, 1997 Peer Instruction: A User’s Manual (Prentice-Hall, Upper Saddle River, NJ).
[6] Laws, Priscilla W, 1991, “Calculus-based physics without lectures,” Phys. Today 44 (12), 24–31
[7] University of Colorado (2017) Moving Man Simulation. Retrieved at March 1, 2018, from the website https://phet.colorado.edu/en/simulation/moving-man