The conversational framework and the ISE “Basketball Shot” video analysis activity.

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Abstract

Inspiring Science Education (ISE) (http://www.inspiringscience.eu/) is an EU funded initiative that seeks to further the use of inquiry-based science learning (IBSL) through the medium of ICT in the classroom.

The Basketball Shot is a scenario (lesson plan) that involves the use of video capture to help the student investigate the concepts of speed, velocity and acceleration. Using the LoggerPro® programme from Vernier Software and Technology (http://www.vernier.com/products/software/lp/), video is captured of a player throwing a ball towards the basket. The ball does not reach the basket, but instead bounces on the floor and continues its motion. The concept of constant velocity, vectors, acceleration in two dimensions is therefore demonstrated. Moreover, a connection with mathematics is established where the relevancy of linear and quadratic equations are clearly demonstrated in the context of the motion of the ball. The effectiveness of this lesson plan is evaluated through the lens of the “Conversational Framework” underpinned by the five stage inquiry-based learning approach.

Keywords

Physics, inquiry-based learning, velocity, acceleration, data analysis, video capture, conversational framework

I. Introduction

The need to ensure that practical work is a key element of learning science is espoused by many scientists and educators (Watson, Swain, & McRobbie, 2004; Watson, 2008). According to Watson (2008), the answer “lies in the nature and contents of the activities and the aims they are trying to achieve” (p. 57). No matter what view ones subscribes to, the action of performing experimentation “has been singled out as a key indicator of doing science” (Thomas and Banks, 2009, p. 24). Students should appreciate the importance of the relationship between observation and theory, and that not all discoveries are made in isolation by a reclusive scientist (Bauer, 1992 cited in Thomas and Banks, 2009), and that a pre-existing theoretical frame of reference guides the research in a potential fruitful direction (Medawar, 1967 cited in Thomas and Banks, 2009). It is therefore important that students get a clear picture of how science is “done” and not be influenced by the classical picture of a rigid, idealised and impersonal perception of a dull and dreary laboratory (Bauer, 1992 cited in Thomas and Banks, 2009). As referenced by Collins (2000, cited in Thomas and Banks, 2009), we need to consider who is science education for? The extent to which we include practical in science will need to address the needs of the potential scientist as well as those who will not continue a career in science. Whilst Bauer (1992, cited Thomas and Banks, 2009) suggests that the achievement of “widespread scientific literacy is an impossible illusion”, nonetheless at a bare minimum, practical work will need to inform the specific needs of the citizen scientist (Jenkins, 2004), as well as the professional scientist (Collins, 2001 cited in Thomas and Banks, 2009). However, the problem exists that school science as it is taught does not represent the practice of science in the real world (Reiss, 2004).

The curriculum challenge in the modern environment is how to make practical work more interesting and relevant to 15-18 year olds, and less boring (Harlen, 1999; 2010). The role that practical work plays in the learning of science has been debated extensively in the literature, both in a positive and negative way. However, the central tenet of any educational activity must always be a purpose and a goal (whether it is a class discussion or a practical session) and that needs to be clearly defined, which is not always obvious in modern day teaching (Murphy, Scanlon, & Lunn, 2009). Positive engagement of the student and the transfer of the ownership of the learning to the student giving them a responsibility, and authority, over this process, are pivotal to an active engagement in the learning process (Crouch & Mazur, 2001; November, 2012). The rationale for such an approach benefits from a social constructivist approach, where a mechanism is put in place for the teacher to understand the true nature of the “learning demands” of the students as be balance between authoritative and dialogic discourses is achieved (Leach & Scott, 2003). Building on this reasoning, the Inquiry-Based Based Learning (IBL) role in this process is of particular interest.

a. The Basketball Shot Lesson Plan

The Basketball ICT artefact was designed as a lesson plan accessible through the ISE web site http://portal.opendiscoveryspace.eu/repository-tool for students at various levels; preferably in class to promote collaborative inquiry-based learning (IBL) underpinned by a teacher directed structured approach. The involvement of the teacher is pivotal in guiding the students through the 5 stages of the IBL approach. Whilst there exists several approaches to inquiry based learning (Table 1), the structured approach was deemed most suitable for the Basketball shot due to the conceptual difficulties many students experience in the study of kinematic.

A. Structured	Strongly teacher-directed. Students follow their teacher's direction in pursuing a scientific investigation to produce some form of prescribed product, e.g. they investigate a question provided by the teacher through procedures that the teacher determines, and receive detailed step-by step instructions for each stage of their investigation.
B. Guided	More loosely scaffolded. Students take some responsibility for establishing the direction and methods of their inquiry. The teacher helps students to develop investigations, for example offering a pool of possible inquiry questions from which students select, and proposing guidelines on methods.
C. Open	Strongly student-directed. Students take the lead in establishing the inquiry question and methods, while benefiting from teacher support. For example, students initiate the inquiry process by generating scientific questions and take their own decisions about the design and conduct of the inquiry and the communication of results.
D. Coupled	A combination of two types of inquiry, for example a guided inquiry phase followed by an open inquiry phase.

Table 1. Inquiry Based Learning Types for IBL (adapted from National Research Council, USA, 2000)

The lesson plans covers common kinematic elements found in all secondary education in Europe. A basic computer skill-set is all that is required for the lesson plan. Each lesson plan has linear structure of 5 tabs, which follow through the 5 stages of the IBL structure (Figure 1) and is designed to last 50-60 minutes.

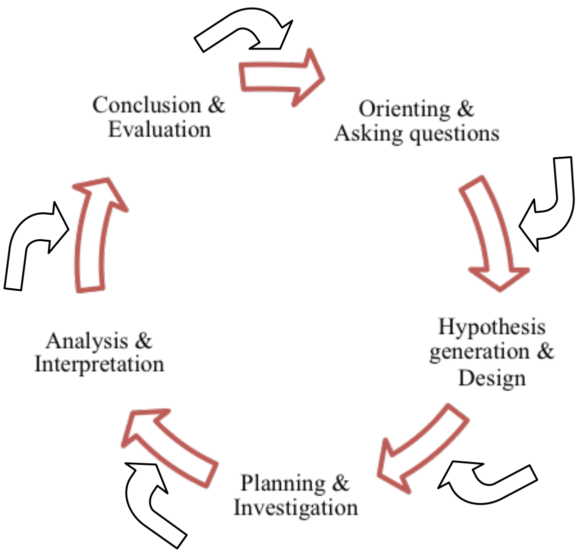

Figure 1 - The 5 stage model supporting the Basketball activity

At the end of the 5 IBL sections there is a text to speech function that will play the narrative if required, and also a function to increase the text size for ease of reading. The 5 stages are represented in a linear way using different coloured tabs running across the top of the screen as each stage is sequentially followed. The teaching sequence is essentially metaphoric, where real life example of motion is analysed.

The wide range of resources is provided by extra plug-in resources, giving the possibility to use real-world data to describe scenarios such as motion analysis in physics as an example. The web resource works alongside a video capture software program which graphs the data as the student manipulates the video by using tools within the LoggerPro programme. This programme is not integrated into the portal.

Students have access to further information by clicking optional links. Similarly, the scenario contained hidden teacher sections with back up material and guidance, suggested questions (with answers) and extra materials for more advanced students. At the end of each IBL sequence there are two inquiry-based question posed on the activities of the section just studied. The teacher is given guidelines as to how to grade the answers. There is no instantaneous feedback from the web site.

As the class session progresses, students are encouraged to work in groups as they problem solve the activities that are part of each stage. The learning outcomes will be addressed through a linear progression through the teaching sections. There will be links to further resources for the students, which will be designed to invite students to reflect on their learning.
At the end of the scenario, students engage in a group discussion about the concepts covered and will be invited to suggest their own experiments by importing their own video content in the programme thereby encouraging social constructivism. A screen shot of the program is shown in Figure 2

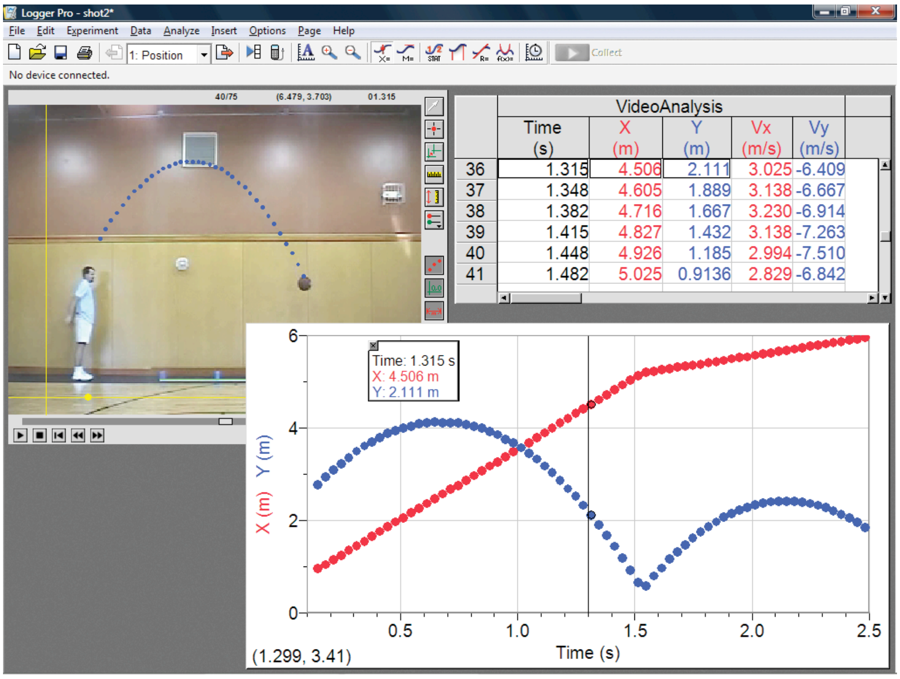

Figure 2 – Screenshot of LoggerPro Basketball Shot

b. Interactivity

Student and teachers access the different lesson plans by registering on the Inspiring Science portal at http://www.inspiring-science-education.net/participate The lesson plans are searchable through key words or by subject content. Teachers and student launch the pre-installed Vernier LoggerPro program on their own computers to access the video analysis and data manipulation features. The online scenario lesson plans provide detailed guidance by using LoggerPro screenshots of each stage of the structured IBL cycle backed up with extensive background theory and problem solving exercises.

The design of the Basketball artifact ensures that students are not passive learners, but there is a specific emphasis on "task decomposition" (Holliman & Ross, 2011) to underline the social constructivist approach. Therefore a level of interactivity is an important aspect of the resource, where students are given feedback on their progress, scaffolded by the structured pedagogical approach. In particular, the level of interactivity follows the advice of Sims (1997, cited in Holliman & Ross, 2011) that it should be both contextual and structural, whereby the students can work with real world data. However, in balancing against criticisms levelled at such a prescriptive approach, navigational trails are embedded to allow the student to discuss related topics in more depth and to sub-tasks to engage the students in hypothesis building and making predictions (Holliman & Ross, 2011). The achievement of an optimum balance between a liberalised structure necessary to develop the concepts gradually and the availability of "total free expression" was deemed necessary for a successful structured IBL approach.

c. Feedback and response

Functionality of the scenario was based on a liberalised design with logical "jump off" points to facilitate teacher driven structured discussion. The programme was designed and utilised only artifacts that are easy to and intuitive to use. Feedback is given by the tutor, and not by an automated computer response. The teacher was guided to give feedback that fell into three categories of achievers, namely: low, medium and high. Positive feedback was encouraged (individually and a group working), no matter what the circumstances, in keeping with research that shows this approach tends to have a better long term positive effect on students (Crouch & Mazur, 2001; Dowd, 2012; November, 2012).

d. Nature and purpose of activities

Research has shown that "generating predictions before conducting an experiment results in more inquiry learning than designing and conducting the experiment" (Linn, 2013, p. 12), and therefore this scenario used predictions as a key concept in the teacher guided sessions. According to Laurillard (2003) teachers need to support the learning process as fully as possible for the designated task or learning goal.

Based on the "Conversational Framework" model proposed by Laurillard (2003) the lesson plan was designed so that a structured scaffolded IBL support from the teacher was the pivotal component to success implimentation. The motion of the basketball was discussed through an "intrinsic" feedback loop, facilitated by the teachers, of what is exactly "happening" to the ball in motion. This setting of goals, action and then feedback cycle was the core of the scenario (Laurillard, 2003). The importance of adaptive media in learning science, is stressed by Laurillard (ibid), because of the value inherent in intrinsic feedback. Likewise, extrinsic feedback for a greater general understanding of concepts is also emphasised. Both these principles are underpinned by this scenario approach where formative feedback, both individually and in groups, helps build students' cognition of the underlying theory and the real world event (Laurillard, 2003). This approach resonated also with the Vygotskian Zone of Proximal Development (ZPD) (Leach & Scott, 2004). At each point in the 5 stage IBL approach, the concepts of speed, velocity and acceleration are gradually constructed in the social setting of the classroom. They are scaffolded by teacher's guided discussion where students are invited to add to discussions and make predictions. Further resources are provided to the teacher in "hidden" areas of the portal, providing all of the theoretical support material needed without having to find external resources.

Learners are encouraged to test their own hypotheses, engage in group sessions and are asked questions at the end of each stage on which they are given supportive feedback. Students complete the activity of tracking the ball themselves, and watching as the graph of the motion (in 2D) unfolds as they continue the tracking. Teacher guided activities assist the students in understanding the concepts and how to use the graphing tools to further analyse the motion (linear, slopes, quadratic modelling etc). Making the connection between the graph, the real-world data and the mathematical concepts is essentially the role of the teacher. A separate screen-cast video with narrative is available for all scenarios, which can be used for both teacher and student for offline revision purposes together with links to PheT animations to reinforce learning which are accessed via hyperlinks at the end of the lesson. In terms of Laurillard's Conversational Framework (2003) the learning sequence is delineated in Figure 3.

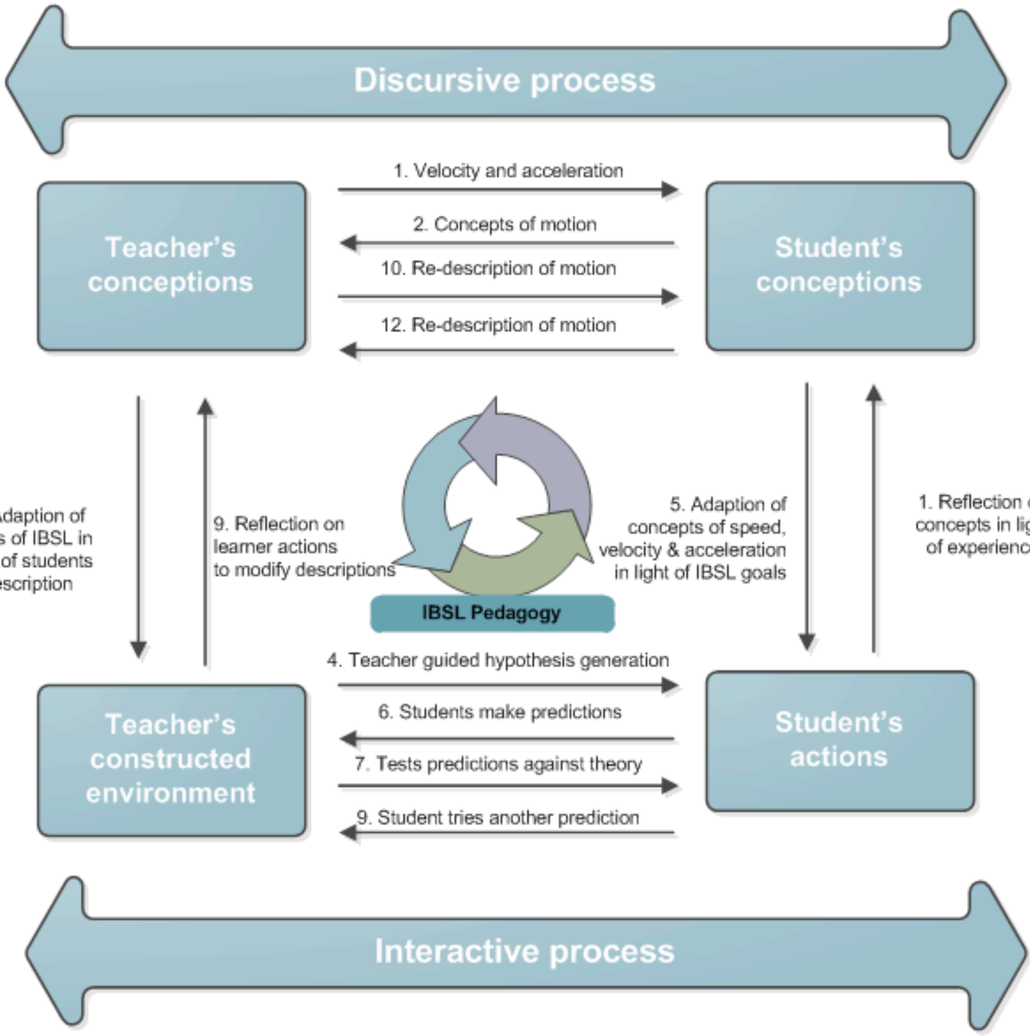

Figure 3– Adapted from the Laurillard's Conversational Framework for Basketball Activity (Laurillard, 2003)

The "Basketball Shot" learning scenario (lesson plan) is summarised in Table 2 in terms of the learning activities, affordances and design features and specific examples of the lesson plan. Table 2 was used to guide the learning activity in terms of the conversational framework steps 1 to 10.

Online and/or LoggerPro Learning activity	Affordances/Design features	Specific Stages & Instances
Attending, apprehending — in the student's conceptual response to the teacher's input, at 1 and 10 of Figure 3 above.	Vicarious experiences and/or supplantation of experiences of ideas and concepts of the learning scenario	Goal: to introduce concepts of speed, velocity and acceleration. Web based materials comprise an interplay between linear narrative sequences, interactive exercises using real world data video analysis and data graphing package structured through a sequence of teaching sessions that follow a 5 stage IBSL sequence. Links of other web resources are strategically located throughout the narrative. Questions posed at the end of each cycle to gauge students' cognition. Tutor guided discussions through PBL and group discussions with hands on activities. Students work with real world data and comparisons with 2D graphs are made. The video can be tracked with propriety tools and a simultaneous graph appears, showing motion of ball in two components (x and y). Students can experiment with their own video and try new ideas and scenarios after completion of the "set" lesson.
Investigating, exploring — in the adaptation-action-feedback-reflection loop at 5, 6, 7, 11 of Figure 3	Offer student the means to select or negotiate their own task goal for searching resources. Set a task goal to motivate focused searching of resources.	The students are asked to reflect at stages in the lesson, with sub activities that serve a number of purposes (mostly reinforcement of learning, activities related to real world examples etc). The lesson plan has embedded links and animations that look at the concepts in a slightly different way, or are in a closely allied construct. In this way relevancy and meaning is enhanced using current topics and students' interest is maintained throughout. There are 5 main teaching sequences based on IBSL (Figure 1 above). Each section has set tasks for students to engage in collaborative learning and predictions (in class) or self directed learning by links to relevant resources.

Online and/or LoggerPro Learning activity	Affordances/Design features	Specific Stages & Instances
Discussing, debating — in the discursive process between teacher and students at 1, 2, 10, 12 of Figure 3.	Generate the questions and exercises that will elicit likely misconceptions, or representational difficulties. Encourage students' articulation of conceptions and perspectives.	Sections each contain learning outcomes so students are aware of where the lesson is leading. Reflection is an important part of the IBSL sequences and questions are posed at the end of each sequence, and also some reflective areas within each sequence. Students are asked to relate back continuously to real world examples and any prior knowledge, and challenge any preconceptions they may have.
Experimenting, practising — in the goal-action-feedback-reflection-adaptation-modification cycle at 4, 6, 7, 11, 5, 8 of Figure 3.	Define the goals against which students can compare their own results with the intrinsic feedback or with a model answer to modify their next action. Questions on topic goal that require students to use their experience at the interactive task level.	The goals are directed by the teacher in class. The lesson plan has teacher sections only accessible to the teacher to guide them through the enquiry process. The linear structure contains "jump off" points that allow for deeper discussion and reflection. Questions posed at the end of each section build on students' prior knowledge and direct experience of the preceding part of the lesson plan (or experiment). Since data is real world data, a better relationship is built with the student and the activity.
Articulating, expressing — in the student's discursive activities, feed back to the teacher at 2 and 12 of Figure 3.	Ask students to reflect on theirs and others' conceptions, and on the goal-action-feedback cycle they have experienced.	The final part of the 5 stage IBSL sequence is conclusion and evaluation of the lesson (or experiment). Students are encouraged to discuss the overarching learning outcomes and reflect on what they have learned. They are asked to discuss how their learning and understanding has changed from any preconceived misconceptions. The community of practise set up on the portal allows for discussions with schools across Europe and beyond, and students can share results. A questionnaire is embedded to enable students to leave feedback on what they through was good, or bad, about the scenario.

Table 2 – An analysis of the scenario using the conversational framework (Laurillard, 2004).

Finally, as a checklist for the overall usability and suitability of an electronic based learning scenario, the sources in the extant literature suggest such platforms should add value to the experience whilst maintaining a concrete connection with authentic science learning. The following checklist addresses the design considerations recommended for on line learning activities.

Pedagogical requirement for online activities?	Comment	Literature reference
Can the resource must have the potential to facilitate more effective learning	Yes. Student can input their own video content and analyse almost anything	(Wellington, 2004)
Does resource take account of prior learning?	Yes. Through the program and the IBSL pedagogy. The resource challenges the prior knowledge of the student and makes connections with existing ideas.	Holliman & Ross (2011); (Linn, 2013)
Does the resource add value to the learning experience?	Yes. Through rapid data capture and manipulation of data. The resolving of motion in 2 components is difficult to show in a textbook	Wellington (2004)
Are conventional teaching methods adequate?	Yes, it can be. It is very difficult to adequately explain the true differences between speed and velocity. An excellent teacher is normally required.	Holliman & Ross (2011)
Should the ICT resource replace or enhance the conventional teaching methods?	It should be used in tandem with traditional methods to enhance learning.	Holliman & Ross (2011)
Does student require additional skills to use the ICT resource?	No. Any student with basic skills	Holliman & Ross (2011)
Does the ICT resource address all learning outcomes?	Yes, based on IBSL & PBL approaches	Holliman & Ross (2011)
Does the ICT resource motivate and give confidence?	Yes, students are able to use real world data to investigate complex concepts.	Holliman & Ross (2011); Linn (2013)
Is the simulation used in the ICT resource valid for teacher and student?	Yes, because it is a real world data example of a video of someone throwing a basketball.	Holliman & Ross (2011)
Does ICT resource allow for predictions?	Yes, the programme is specifically defined by this approach	(Barton, 1997; Barton, Still, & Barton, 2004; Osborne & Hennessy, 2003; Rogers & Barton, 2004)

Table 3 – Summary of questions posed based on scholarly literature on design considerations for electronic learning lesson plans

The structured approach advocated for the Basketball scenario guides the student through the 5 stages of the IBSL process. Therefore the Basketball scenario was designed as a structured activity in recognition of the conceptual challenges facing student in the analysis of motion graphing. Moreover, the concepts of velocity and acceleration can also present cognitive difficulties for many students. The Basketball shot, therefore, is a scenario that has been designed as a structured activity where the students follow the direction of the teacher with the conversational framework in this case providing the structure that allows the student to investigate the question provided by the teacher through procedures that the teacher determines, and receive detailed step-by-step instructions for each stage of their investigation.

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