Scripting Science Inquiry Learning in CSCL Classrooms

Organizers and Participants
Annelies Raes, Tammy Schellens, & Bram De Wever, Dept. of Educational Studies, Ghent University, Belgium
Email: annelies.raes@ugent.be, tammy.schellens@ugent.be, bram.dewever@ugent.be
Ingo Kollar, Christof Wecker, Sybille Langer, & Frank Fischer, Ludwig-Maximilians-Universität, Germany
ingo.kollar@psy.lmu.de, christof.wecker@psy.lmu.de, sybille.langer@psy.lmu.de, frank.fischer@psy.lmu.de
Mike Tissenbaum, James D. Slotta, Ontario Institute for Studies in Education, University of Toronto, Canada
Email: miketissenbaum@gmail.com, jslotta@oise.utoronto.ca
Vanessa L. Peters & Nancy Butler Songer, University of Michigan, School of Education, USA
Email: vlpeters@umich.edu, songer@umich.edu
Chair: Bram De Wever, Ghent University, Belgium, bram.dewever@ugent.be
Discussant: Pierre Dillenbourg, Ecole Polytechnique Fédérale de Lausanne, Switzerland,
pierre.dillenbourg@epfl.ch

Abstract: Research on scripting computer-supported collaborative learning (CSCL) has recently received a lot of attention. However, most findings within this research grew out of studies focusing scripting online collaborative learning activities that often had an asynchronous nature and were conducted in artificial settings. This symposium includes an international set of presenters from Belgium, Canada, Germany, and the USA and brings together four studies that focus on scripting face-to-face "classroom" activities, seeing the "classroom" as a formal physical learning environment. The common denominator of the contributions is that they are all field studies focusing on computer-supported science inquiry learning, aiming to investigate the optimal conditions for organizing these inquiry learning environments. Each paper will present the research context, method, data, and conclusions on how scripting can be implemented to support science inquiry learning. Broader implications of the findings of these studies will be discussed with the audience.

Aim and Structure of this Symposium

The main aim of this symposium is to highlight the added value of scripting CSCL activities in authentic science classrooms. Within the field of Computer-Supported Collaborative Learning, a lot of attention has been paid to how learning environments need to be organized in order to promote students' learning. There is widespread agreement that technology in itself does not support learning (Lai, 2008) and that technology should be well integrated into a learning environment in order to realize its full potential (Weinberger, Reiserer, Ertl, Fischer, & Mandl, 2005). In this respect, the introduction of scripts (see Kobbe et al., 2007) has been proven useful. More specifically, earlier research showed that "scripts have proven to be a powerful instructional approach to foster specific collaborative activities and interaction patterns, such as identifying conceptual differences, asking thought-provoking questions, integrating multiple perspectives, and/or constructing arguments and counter-arguments" (Weinberger, Stegmann, & Fischer, 2010; cf. a recent discussion at CSCL 2011, see Gijlers, van Dijk, & Weinberger, 2011, p. 1071). While a lot of research towards scripting has been focusing on online – usually asynchronous – learning environments, the present symposium focuses on studying scripting in CSCL authentic classroom settings. Within these settings, the collaboration script is functioning next to, or in addition with, the teacher in the learning environment or classroom.

Through bringing together the work of scholars from four distinct research groups from four different countries, we hope to provide a diversity of perspectives and empirical data to widen the discussion on the issue of implementing scripting in authentic CSCL situations. This symposium comprises four papers, which all focus on (1) science inquiry learning, (2) in authentic situations, (3) supported by technology, (4) in secondary education, and (5) the role of scripting in these learning environments. The first two studies focus more on collaboration scripts within the classrooms, in order to find ways how to introduce small group collaboration scripts and potentially combine them with the teacher as another potential source of support for the learners. The third study investigates an emergent script introducing user-generated content in a physics learning environment. The fourth study centers on implementing a mobile technology application to script students' activities while performing field observations.

The discussant, Pierre Dillenbourg, who is not affiliated with any of these research programs, but has studied scripting in high detail, will synthesize the ideas and advances in this work and lead a discussion amongst the participants and the audience. He will invite (a) the participants to connect and compare their findings and put forward specific implications for inquiry based science learning in TEL classrooms and (b) the audience to relate to and critically comment on these findings and scientific and practical implications.

Paper 1: Scripting Computer-Supported Collaborative Information Problem Solving on the Web

Annelies Raes, Tammy Schellens, & Bram De Wever

Introduction

Previous research has indicated that learning science content by means of a web-based inquiry project is effective in enhancing learners' knowledge acquisition (Slotta & Linn, 2009) and their metacognitive awareness while solving information problems on the web (Raes, Schellens, De Wever, 2011). However, since students in a web-based inquiry project usually work together in small groups, it is vital to pay attention to the collaboration process and students' (socially) shared regulation, in addition to processes on an individual level (Spada & Rummel, 2005; Vauras, Iiskala, Kajamies, Kinnunen, & Lehtinen, 2003). In this respect, this study focuses on both the individual and collaborative processes playing when students learn by means of a web-based inquiry science project and deal with information problems in an authentic classroom setting. Moreover, it is questioned whether the quality of collaboration and shared regulation can be improved by integrating a collaboration script and subsequently, if this also leads to higher individual learning outcomes. Providing students with a collaboration script is put forth as a way to support computer-supported collaborative learning (CSCL) since collaboration scripts facilitate social and cognitive processes of collaborative learning by shaping the way learners interact with each other (Kobbe et al., 2007; Kollar, Fischer & Slotta, 2007). The script developed for this study particularly focused on the aspect of roles and the mechanisms task distribution and sequencing aiming at prompting the regulatory skills that critical information problem solving on the web entails (Brand-Gruwel, Wopereis, & Walraven, 2009). The one student was the 'executer' assigned to operate the computer and typing the answers, the other student was the 'web detective' assigned to critically supervise the online search activities. Students were prompted to switch roles during the project.

The effects of the integration of such a collaboration script are investigated through a quasi-experimental field study. In total 220 students from 13 different secondary school classes were involved in this study. The intervention consisted of the implementation of a web-based collaborative inquiry project lasting 4 sessions of 50 minutes. During the first session, secondary students completed an individual pretest and were introduced to the Web-based project provided on the Web-based Inquiry Science Environment (WISE) (Slotta & Linn, 2009). They were free to choose their partner and started the first introductory activity of the WISE-project in dyads. Students worked in the same dyads during the whole intervention and navigated through the sequence of inquiry activities using the inquiry map in the online learning environment. During the project, students were asked to write their answers down in reflection notes. Finally, all students completed an individual posttest. Seven classes were provided with a collaboration script embedded in the WISE-project (experimental condition, N = 97 students), six classes were not provided with this collaboration script (control condition, N = 107 students).

Data and Methods

The study used a mixed-methods approach in which both quantitative and qualitative sources of evidence are triangulated. The quantitative part of the study consisted of pretest-posttest-comparisons regarding the outcome measures knowledge acquisition and metacognitive awareness during information problem solving on the Web. The latter variable was measured by facing students with an unfamiliar information problem in pretest and posttest, more specifically a scientific controversy. They were assigned to take up a particular position that they needed to justify with appropriate evidence from the web to support their claim. After performing this IPS-task students were asked to fill out an adapted version of the Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994). This self-report inventory was used to measure students' perception about their metacognitive and strategic activities while performing the task. Moreover, students' answers during the web-based projects were scored and summed to result in a process score for every dyad. Quality of collaboration was measured by means of a self-perception questionnaire filled out by the students after finishing the project. In addition, the collaborative processes of a subset of these students (35 dyads) were videotaped and the quality of collaboration was rated based on the scheme of Meier, Spada and Rummel (2007).

In this study the students worked together in small groups within classes, and as such, the problem under investigation has a clear hierarchical structure. In this respect, the analysis of test data at an individual level raises a methodological issue frequently discussed in research on group learning and collaborative problem-solving (e.g. Cress, 2008; De Wever, Van Keer, Schellens, & Valcke, 2007). Because of this, the Hierarchical Linear Modeling is used for testing main effects and interaction effects of predictor variables on different levels. The independent variables that were taken into account were gender, achievement level and perceived quality of collaboration at student level; group composition based on gender, group composition based on achievement and students' process score at group level; and academic track (science track vs. general track) and condition (collaboration script present vs. absent) at class level.

The software MLwiN 2.23 for multilevel analysis was used to analyze the hierarchical data. A three-step procedure has been followed to analyze the effects of the presented explanatory variables on the dependent variables. The first step consists of the estimation of a four-level conceptual null model, which serves as a baseline model. This unconditional null model without any predictor variables provides both the overall pretest score and the overall learning gain for all students across all groups and classes. Moreover this null model will, by means of the Intra-Class-Correlation (ICC), answer the question if the outcome measures vary among students, across groups and across classes. The second step concerns the input of the main explanatory variables in the fixed part of the model and allows cross-level interactions between student and class characteristics. This will give insight in the differential effects for different groups of students with different student and class characteristics. Finally, in the third step, the aggregated characteristics based on gender and achievement level, i.e. group composition, was added to the model. The results of these quantitative multilevel analyses will be presented and discussed at the conference in addition with qualitative analyses on the collaborative inquiry activities of the 35 different groups. These in-depth analyses will deepen the quantitative results and will give insight in how students deal or deal not with the embedded collaboration script and how this influences their learning performances and outcomes.

Paper 2: Using Small Group and Classroom Scripts to Foster High School Students' Acquisition of Online Search Competence

Ingo Kollar, Christof Wecker, Sybille Langer, & Frank Fischer

Introduction

An important strategy in developing well-grounded positions in societal debates on science issues, such as whether pre-implantation diagnostics should be allowed or not, is to search the Internet for relevant information. However, finding information that is relevant, impartial, credible and scientifically sound is a challenging task for high school students. One promising approach to foster high school students' online search competence is (web-based) collaborative inquiry learning. Yet, without appropriate scaffolding, inquiry learning is likely to fail (de Jong, 2006). This contribution looks at the effects of two kinds of scaffolds that can be used during collaborative inquiry learning. First, it investigates *small group collaboration scripts* that specify, sequence and distribute learning activities among roles that are filled by the members of a small group (e.g., Kollar, Fischer & Hesse, 2006). With respect to online search, such a script may for example have one learner suggest certain search terms, while her learning partner is asked to anticipate what unwanted search results will likely be triggered by these terms. Similar task distributions could be realized for further steps of the online search process (e.g., selecting links from a hit list or finding information on a selected website). Although prior research has shown that small group collaboration scripts can be designed to foster quite some variety of domain-general skills (e.g., argumentation; see Stegmann, Weinberger, & Fischer, 2007), it is still an open question whether they can also foster students' online search competence. As a second kind of scaffold, we look at *classroom scripts* that distribute learning activities over the different social planes of the classroom (Dillenbourg & Jermann, 2007). With respect to online search, one could imagine a classroom script that first has the teacher model successful online search behavior (plenary activity), followed by dyadic and then individualized Internet search. We compared the effects of two classroom scripts (variant 1: all search activities were carried out on the small group level, i.e. in dyads, vs. variant 2: search activities changed between the plenary level, i.e. through teacher-student or student-student modeling, and the small group level) that were either enriched or not enriched by a small-group collaboration script. With respect to classroom scripts, we expected that the script that included plenary (i.e. modeling) in addition to small group activities (variant 2) would work better than the script that located all search activities on the small group level (variant 1). We also expected that when all search activities are conducted on the small group level (variant 1 of the classroom script), a small group collaboration script would effectively scaffold learners' acquisition of online search competence. Most effective, however, should be the combination of a small-group collaboration script and a classroom script that included search activities on the plenary and the small-group level to be.

Data and Methods

Participants were 174 9^{th} graders from eight classes from urban high schools (90 female, 84 male). Within regular Biology lessons led by the students' regular Biology teachers, who were trained to implement the experimental condition, their class was assigned to one of the four experimental conditions of a 2x2 design (see below). Learners were equipped with laptops and worked on a web-based inquiry learning curriculum unit on Genetic Engineering. The main task was to develop a well-grounded position towards the question whether Genetic Engineering should be allowed or not. The learning phase spanned seven regular Biology lessons and involved considerable time to search the Internet for arguments and evidence. During these search phases, we realized a 2x2-factorial design with the factors "small-group collaboration script" (present vs. not present) and "type of classroom script" (small-group level only vs. small-group and plenary level). In all groups, we implemented collaborative browsing, i.e., during their online search processes, the laptops of the two co-present partners of a dyad were connected so that the browser displayed identical web pages on both screens, no matter who of the two learners had accessed them. The *small-group collaboration script* was implemented as a browser plug-in that segmented the browser window into two frames (a scaffolding frame and the regular browser frame). The scaffolding frame displayed prompts related to the actual step in the search process (e.g., Google start page, Google hit list, chosen web site) and distributed them between the two learning partners. For example, accompanying a Google hit list, the scaffolding frame displayed prompts such as "Suggest a link which from your perspective is likely to contain valuable information" to one learner and "Listen to your partner's suggestion and estimate whether the link s/he suggested is (a) impartial, (b) relevant and (c) scientifically grounded" to his/her learning partner. In the conditions without the small-group collaboration script, no prompts were displayed. The *type of classroom script* was also manipulated during the online search phases. In the small-group level only classroom script, online search was to be conducted in dyads. In the classroom script with both the small-group and the plenary level, single steps were modeled in front of the class before this activity was to be conducted on a dyadic level.

Online search competence was measured by the students' performance in an individual test that asked them to describe in as much detail as possible how they would use the Internet to form a position concerning the question whether nuclear power plants should be abandoned. 15% of the data included in the analysis was analyzed by two independent coders. Coding was based on a scheme that captured adequate steps and important quality characteristics during successful online search (e.g., judge the credibility of a website). Intra-class correlation was sufficient ($ICC = .83$). An analogous test on a different topic was used as a pretest ($ICC = .51$).

Results and Discussion

Results indicated that as expected, when no small-group collaboration script was provided, the classroom script with online search activities both on the plenary and the small group level led to higher levels of online search competence than the classroom script that located all search activities on the small group level, $F(1,66) = 23.89$, $p < .01$, *partial* $Eta^2 = .27$. Also confirming our expectations, the small group collaboration script proved more effective than no small group script, when all search activities were located on the small group level, $F(1,90) = 10.06$, $p < .01$, *partial* $Eta^2 = .10$). Adding to these results, first results from further in depth process analyses revealed that both the small group collaboration script and the classroom script comprising activities on both the plenary and the small group level led to higher quality levels of online search behavior than no such support. In contrast to our hypothesis, however, the combination of the small group collaboration script and the classroom script that alternated plenary and small group search phases was not the most effective concerning the learners' acquisition of online search competence. When the classroom script covered both the small-group and the plenary level, adding the small-group collaboration script had a slight negative effect, $F(1,74) = 4.27$, $p < .05$, *partial* $Eta^2 = .06$. Thus, it appears that modeling as part of a classroom script can be regarded as a viable alternative to scripting small group collaboration (see also Rummel & Spada, 2005).

Paper 3: Scripting Collective Inquiry in High School Physics

Mike Tissenbaum & James D. Slotta

Introduction

Our work focuses on developing a smart classroom for knowledge communities where all students are actively involved in the production, aggregation, and assessment of science content (Ulrich et al., 2008; Ito et al., 2009). Having students contribute their own educational content provides opportunities for them to understand connections amongst often disparate pieces of information within a domain. The most common way of creating such connections is by assigning meta-data, or "tags", to individual content (Mathes, 2004; Wiley, 2000)., allowing individuals to assign descriptors without needing to know about every other piece of content that shares the same designation. They can rely on the emergence of a collective data set, guided by the tags, to reveal meaningful connections and increased usefulness of content elements (Hayman & Lothian, 2007).

To define and coordinate the flow of materials, activities and interactions within such complex collaborative inquiry, learning scientists have advanced the notions of scripting and orchestration (Dillenbourg, Jarvela & Fischer, 2009; Dimitriadis, 2001), where specified learning and interaction designs (i.e., "the script") are enacted ("the orchestration"). The script can be seen as a formalism that captures the pedagogical structure of a learning design (e.g., student must upload two relevant videos) and collaboration patterns between students, their peers, and the teacher. When user-contributed materials are introduced, the script becomes more open-ended, and any design must be left somewhat "unbound" allowing specific themes, directions or content collections to emerge during its enactment (Peters & Slotta, 2010). Technology-supported inquiry learning environments offer a proven means of scaffolding student learning, encouraging reflection, providing timely access to tools and materials, and engaging learners collaboratively (Slotta & Linn, 2009).

This present paper reports on our efforts to formalize scripts, in terms of the roles, groupings, learning contexts, technology, materials, and interaction patterns for inquiry and knowledge communities. Towards developing a formal concept of scripting, we conducted a series of quasi-experimental studies, beginning with investigations of small, controlled “micro” scripts, followed by more complex “macro” scripts, where students contribute content and actively use the emerging aggregate knowledge base. Below, we report on two studies of micro scripts, and a larger macro script to support high school physics students as they collectively upload content, solve, tag and explain physics problems, then re-use those resources in scripted inquiry activities. Students were scaffolded in all aspects the script by a smart classroom technology framework (Slotta, 2010).

Data and Methods: Three Successive Designs of Collaborative Inquiry Scripts

Our first iteration investigated a collaborative inquiry script called Tag, Answer, and Reflect (TAR) where students uploaded their responses to homework problems, including their selection of “physics principle tags,” then reflected on the aggregate set of tags and explanations. We investigated the following questions: (1) Did TAR help students make connections between physics principles? (2) How did different technologies (large format displays, customized views) help the teacher to understand students’ knowledge, for adjustments to the script before, and orchestration of the class during its enactment? (3) Did a visualization of student work help students make connections between physics principles? Two different comparisons were examined: First, individuals were compared with small groups as they examined aggregated responses from the community; second, the effect of large-format displays of a groups’ work vs. a single shared laptop was examined in terms of improved student performance. Overall, groups faired significantly better at solving problems (97% overall accuracy) than individuals working at home (80% overall accuracy), with $t=2.02$, and $p<0.05$. The connections made by the groups (80.94%) were also more accurate than individuals (76.57%), although only marginally significant ($p=.081$). The large-format displays were seen to aid the teacher in orchestrating class activities, allowing the detection of student errors, and supporting spontaneous short lectures and discussions with small groups.

Our second iteration sought to extend the TAR script, in order to better aid students in their reflections and investigate the impact of the aggregated knowledge on group performance. Our quasi-experimental study compared two enactments: one where students were provided with access to the aggregated individual responses during their group reflection phase, and one where no aggregates were provided. Groups that received the aggregated responses outscored those who did not ($t=4.13$, $p<0.01$), as measured by a rubric developed with the teacher. These outcomes further our ideas of TAR, including the timing of supports for the teacher.

The third study builds on the findings from the previous two, establishing a “macro” script to address a persistent, year-long curriculum engaging students in tagging and reflecting about homework problems while also uploading and tagging “found examples” from everyday life, including photos, Web URLs, and physics problems. We thus introduce a notion of a “macro” script specifying longer-term patterns, supported by “micro” scripts like TAR. The macro script in this study, called the “collective inquiry cycle,” (CIC) involves five steps: (1) Students submit individual inquiry items to the knowledge base; (2) Collectively (at home or in class) students examine and tag peers’ work, adding comments to explanations; (3) Teacher reviews the community knowledge, to prepare a discussion; (4) In-class activity engages students with collective knowledge artifacts chosen by teacher; (5) Students reflect individually. Macro scripts must allow for adaptations by the teacher, who inserts new materials and activities in response to micro script data (e.g., students’ uploads or TAR data).

The visualization of student work was expanded to represent student ideas as a complex interconnected web of social and semantic relations, allowing students to filter the information to match their own interests and learning needs - making the knowledge not only collective but also personal. The visualization also became the focal point of real-time smart classroom activities where students leveraged the products of the class in creating physics “challenge problems.” Customized views allowed the teacher to gain an understanding of students’ collective knowledge and adjust class activities to better address student needs. Tools were also developed to allow the teacher to assess student work, review individual student progress, and add new materials to the script.

We are currently collecting data from two grade 11 physics classes (n=20, n=25), over a six-month curriculum (Sept, 2011 – March, 2012), divided into three units: Kinematics; Force and Motion; and Energy, Work, and Power. The units are thematically connected, allowing content to carry over between each. We are orchestrating CIC and TAR, including design-based variations of activities and technologies, within each unit. Our final paper will present a pre- post comparison of students’ reasoning about physics principles, an analysis of student contributions to the knowledge base (e.g., the challenge problems they create), and progress in student explanation patterns over time. We will connect these analyses to our notions of a scripting framework.

Conclusions

These studies have addressed two key aspects of a scripting framework for collaborative inquiry. First is the notion of a macro-script for coordinating student activities and teacher interventions over a substantial curricular scope. This includes the capability for student created artifacts, peer exchange, voting and discourse, and teacher adaptations such as additional resources (ie. questions, examples, assessments), as well as the role for emergent artifacts as resources within the script. Second is the development of micro-scripts (e.g. TAR) that can be supported with a smart classroom infrastructure to orchestrate and coordinate student inquiry activities that make use of, and contribute to the community knowledge base These studies have informed our progress toward a scripting framework for engaging students in a knowledge community while providing teachers with the tools to adjust the script in response to the emergent ideas within that community. Further we have begun to formalize an understanding of the informational needs of the teacher in the execution of these scripts.

Paper 4: Development of a Mobile Scripting Application to Support Students' Collection and Analysis of Scientific Data

Vanessa L. Peters & Nancy Butler Songer

Introduction

Research in the learning sciences suggests that even with carefully-designed curricular materials, students develop only a partial understanding of scientific inquiry. While students are able to recognize certain features of inquiry thinking, few students can systematically demonstrate the difference between claim, evidence and reasoning for making predictions or constructing explanations about science (Jeong, Songer, & Lee, 2007). Previous research suggests that more cohesion and scripting are needed to support students' development of complex reasoning skills when collecting and interpreting data for scientific investigations (Metz, 2000). The U.S. College Board has identified the following data-related practices as belonging to an essential skill set for answering questions about scientific problems: justifying the selection of the data type that are needed, designing a plan for data collection and documentation, and evaluating the quality and sources of data (College Board, 2009). Pedagogical scripts can support aspects of scientific inquiry by specifying parts of the learning process such as work phases, task distribution, and the sequencing of activities (Dillenbourg & Jermann, 2007; Peters & Slotta, 2010). Scripts can be communicated through initial instructions by the teacher, integrated into the learning environment (Kollar, Fischer, & Slotta, 2007), or integrated into the design of learning technologies.

This study builds on the strong foundation of empirically-tested activities developed for BioKIDS: Kids' Inquiry of Diverse Species (Songer, 2006) with the development of a new iPod Touch application for supporting students' collection and analysis of scientific data. The goal of the BioKIDS program is to support elementary and middle school students' development of complex reasoning and technological fluency in science through curricular activities that fuse scientific content knowledge with scientific practices. In the BioKIDS curricular units, students work in small groups to collect data on animal or plant species from several different areas in their schoolyard. Students take part in recording field observations that are later used for constructing scientific explanations and making predictions that use their collected data as evidence.

Data and Methods

Working with a technology developer, we developed a customized iPod Touch application that scripts students' recordings of field observations when collecting and classifying data about plant and animal species (Figure 1). The script guides students in data collection through a sequence of panels that asks for specific information about the characteristics of their observed plant or animal, including the habitat, energy role and location of the species. The application's intuitive and icon-driven interface was well-suited for middle school students, including those whose first language was not English. The BioKIDS application did not require that students enter data in one panel before progressing to the next, thus, it was possible for them to omit entering certain information. After students recorded their field observations, the data were aggregated in a repository that organized the information according to biodiversity richness and abundance. Data collected with the BioKIDS application were synched automatically to an online database; data collected with the clipboard were added manually to the repository using the same organizational structure as the iPod Touch application.

The participants in this study were 41 seventh graders from an urban middle school in the Midwestern United States. Students were divided into two groups for data collection: one group used the iPod Touches (n = 21), and the other group used printed worksheets and a clipboard (n = 20). Both groups were taught by the same teacher and completed the same activities. Curriculum implementation differed only in the method students used for recording field observations in their schoolyard. Both groups collected data on the same day and under the same conditions. The teacher was provided with instructions on using the iPod Touch application prior to the study; students were not provided with any such instruction. All field observations from both the iPod Touch and clipboard were analyzed for their completeness and usefulness for providing data-based evidence that could be used for answering scientific questions.

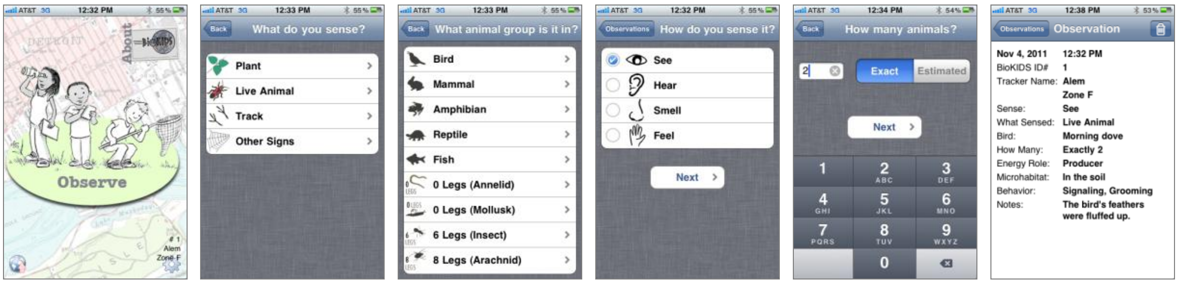

Figure 1. Panel sequence in BioKIDS iPod Touch application for scripting students' observations of field data.

Results and Discussion

Both the iPod Touch and clipboard groups recorded approximately the same number of field observations (79 and 77, respectively), however, there were marked differences between the two groups in terms of the completeness and volume of the collected data. Students using the scripted BioKIDS application noted the habitat and energy role for 100% of their observations, while the clipboard group noted this information for only 5.19% of their observations. Fisher's Exact Test was used to compare the frequency of complete observations for each organism class. An observation was considered complete if it included both the abundance (number of animals/plants) and the richness (type of animal/plant) of the observed organism. Between the two groups, there were significant differences in the recorded observations for mammals (p = .0001), birds (p = .0004), anthropods (p = .0119) and plants (p = .0001). Only the gastropods and annelids (p = .4286) were found to be non-significant between the two groups.

Aside from the novelty and fun-factor, the BioKIDS iPod Touch application presented a significant advantage over the clipboard as a method for data collection when engaging students in inquiry learning. To be meaningful, students need to collect and analyze data in sufficient volume in order to use it productively as evidence for supporting scientific claims. A field observation in this activity was useful if included both the type of animal or plant observed (e.g., prairie falcon, shrub) and the number observed. Unlike traditional pencil-and-paper approaches, technology makes it easy to illustrate the power of large data sets, providing students with enriched opportunities for data analysis that would otherwise be difficult or impossible with smaller sets of data. In the iPod group, the scripted application made it easier for students to record their observations when collecting data, which resulted in a more voluminous and complete repository of field data. One of the goals of BioKIDS is to develop strong learning tools, including technological tools, that support students when collecting and analyzing data, providing them with opportunities for using data-based evidence for answering scientific questions (Songer, 2006). The findings from this study demonstrate the value of technology scripts for supporting a systematic approach to data collection and analysis, and have implications for both technology developers and learning scientists. New technologies bring with them new ways of interacting and understanding different forms of knowledge. Future development work will consider additional scripting capabilities for supporting students' data collection and learning with mobile technologies.

References

Brand-Gruwel, S., Wopereis, I., & Walraven, A. (2009). A descriptive model of information problem solving while using internet. *Computers & Education, 53*(4), 1207-1217. doi: 10.1016/j.compedu.2009.06.004

College Board. (2009). Science: College board standards for college success. New York, NY: The College Board Press.

Cress, U. (2008). The need for considering multilevel analysis in CSCL research-An appeal for the use of more advanced statistical methods. *International Journal of Computer-Supported Collaborative Learning, 3*(1), 69-84. doi: 10.1007/s11412-007-9032-2

de Jong, T. (2006). Technological advances in inquiry learning. *Science, 312*, 532-533.

De Wever, B., Van Keer, H., Schellens, T., & Valcke, M. (2007). Applying multilevel modelling to content analysis data: Methodological issues in the study of role assignment in asynchronous discussion groups. *Learning and Instruction, 17*(4), 436-447. doi: DOI 10.1016/j.learninstruc.2007.04.001

Dillenbourg, P. & Jerman, P. (2007). Designing integrative scripts. In F. Fischer, I. Kollar, H. Mandl, & J. M. Haake (Eds.), *Scripting Computer-Supported Collaborative Learning: Cognitive, computational and educational perspectives* (pp. 275-301). New York: Springer.

Dimitriadis, Y. (2011). Supporting teachers in orchestrating CSCL classrooms. *Research on E-Learning and ICT in Education*, (September), 33-40.

Gijlers, H., van Dijk, A. & Weinberger, A. (2011). How Can Scripts and Awareness Tools Orchestrate Individual and Collaborative Drawing of Elementary Students for Learning Science? In H. Spada, G. Stahl, N. Miyake, & N. Law (Eds.), *Connecting Computer-Supported Collaborative Learning to Policy and Practice: CSCL2011 Conference Proceedings* (Vol. III, pp. 1065-1072). Hong Kong: ISLS.

Hayman, S., & Lothian, N. (2007). Taxonomy directed folksonomies: Integrating user tagging and controlled vocabularies for australian education networks. *World Library and Information Congress: 73RD IFLA General Conference and Council,* (August) 1-27.

Ito, M., Baumer, S., Bittanti, M., Boyd, D., Cody, R., Herr-Stephenson, B., et al. (2009). Hanging out, messing around, and geeking out: Kids living and learning with new media (john D. and catherine T. MacArthur foundation series on digital media and learning) (1st ed.) The MIT Press.

Jeong, H., Songer, N. B., & Lee, S.Y. (2007) Evidentiary competence: Sixth graders' understanding for gathering and interpreting evidence in scientific investigations. *Research in Science Education, 37*(1), 75-97.

Kobbe, L., Weinberger, A., Dillenbourg, P., Harrer, A., Hämäläinen, R., Häkkinen, P., & Fischer, F. (2007). Specifying computer-supported collaboration scripts. *Computer Supported Collaborative Learning, 2*, 211-223.

Kollar, I., Fischer, F., & Hesse, F. W. (2006). Computer-supported collaboration scripts - a conceptual analysis. *Educational Psychology Review, 18*(2), 159-185.

Kollar, I., Fischer, F. & Slotta, J. D. (2007). Internal and external scripts in computer-supported collaborative learning. *Learning and Instruction, 17*(6), 708-721.

Lai, K.W. (2008). ICT supporting the learning process: The premise, reality, and promise. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education. Part one*. (pp. 215-230). New York: Springer.

Mathes, A. (2004). Folksonomies - cooperative classification and communication through shared metadata. *Computer Mediated Communication,* , 1-13.

Meier, A., Spada, H., & Rummel, N. (2007). A rating scheme for assessing the quality of computer-supported collaboration processes. *International Journal of Computer-Supported Collaborative Learning, 2*(1), 63-86. doi: DOI 10.1007/s11412-006-9005-x

Metz, K.E. (2000). Young children's inquiry in biology: Building the knowledge bases to empower independent inquiry. In J. Minstrell & E. van Zee (Eds.), *Inquiring into inquiry in science learning and teaching* (pp. 371-404). Washington, DC: American Association for the Advancement of Science.

Peters, V. L., & Slotta, J. D. (2010). Scaffolding knowledge communities in the classroom: New opportunities in the Web 2.0 era. In M. J. Jacobson & P. Reimann (Eds.), *Designs for learning environments of the future: International perspectives from the learning sciences* (pp. 205-232). New York, NY: Springer.

Raes, A., Schellens, T., & De Wever, B. (2011). Multiple modes of scaffolding to enhance web-based inquiry. In H. Spada, G. Stahl, N. Miyake, & N. Law, N. (Eds.), *Connecting Computer-Supported Collaborative Learning to Policy and Practice: CSCL Conference Proceedings, Vol I. ISLS.*

Rummel, N., & Spada, H. (2005). Learning to collaborate: An instructional approach to promoting collaborative problem solving in computer-mediated settings. *Journal of the Learning Sciences, 14*(2), 201-241.

Schraw, G., & Dennison, R. S. (1994). Assessing Metacognitive Awareness. *Contemporary Educational Psychology, 19*(4), 460-475.

Slotta, J. D. (2010). Evolving the classrooms of the future: The interplay of pedagogy, technology and community. In K. Makitalo-Siegl, F. Kaplan, J. Zottmann & F. Fischer (Eds.), *The classroom of the future orchestrating collaborative learning spaces* (pp. 215-242). Rotterdam: SensePublisher.

Slotta, J. D., & Linn, M. C. (2009). *WISE Science, Web-Based Inquiry in the Classroom*. New York: Teachers College Press.

Songer, N. B. (2006). BioKIDS: An animated conversation on the development of complex reasoning in science. In R. Keith Sawyer, (Ed.) *Cambridge handbook of the learning sciences* (pp. 355-369). New York: Cambridge University Press.

Stegmann, K., Weinberger, A., & Fischer, F. (2007). Facilitating argumentative knowledge construction with computer-supported collaboration scripts. *International Journal of Computer-Supported Collaborative Learning, 2*(4), 421-447.

Vauras, M., Iiskala, T., Kajamies, A., Kinnunen, R., & Lehtinen, E. (2003). Shared-regulation and motivation of collaborating peers: A case analysis. *Psychologia, 46*(1), 19-37.

Ullrich, C., Borau, K., Luo, H., & Tan, X. (2008). Why web 2.0 is good for learning and for research : Principles and prototypes. *International Conference on World Wide Web,* 705-714.

Weinberger, A., Reiserer, M., Ertl, B., Fischer, F., & Mandl, H. (2005). Facilitating collaborative knowledge construction in computer-mediated learning environments with cooperation scripts. In R. Bromme, F. W. Hesse, & H. Spada (Eds.), *Barriers and biases in computer-mediated knowledge communication* (pp. 15-38). Boston: Kluwer.

Weinberger, A., Stegmann, K., & Fischer, F. (2010). Learning to argue online: Scripted groups surpass individuals (unscripted groups do not), *Computers in Human Behavior, 26,* 506-515.

Wiley, D. A. (2000). Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy. *Learning Technology, 2830*(435), 1-35.