STOCHASMOS: The design of a web-based tool for scaffolding students’ reflection in data-rich, inquiry-oriented investigations

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Presentation Overview

- Theoretical background
  - Inquiry
  - Reflection
  - Scaffolding

- The STOCHASMOS learning platform
  - Authoring environment for teachers
  - Learning environment for students

- Scaffolding students’ explanation building
  - Report from a classroom-based study
Inquiry-based learning

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.

Inquiry-based science learning presents students with several challenges, such as planning, monitoring, and evaluating investigations, interpreting data in the light of hypotheses, and creating evidence-based explanations (e.g. Carey et al., 1989; Krajcik et al., 1998; Kuhn et al., 1988; C. Zimmerman, 2000, Sandoval, 2003).

There is a need to support learners in engaging with inquiry reflectively.
"Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world… Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations."

[National Academy of Sciences, National Science Education Standards, 1996 Chapter 2, p.23.]
Reflective inquiry

- We define *reflection* as the ability to monitor and evaluate past and ongoing actions in order to help plan next steps.

- *Reflective inquiry* can be seen as a set of practices that help the inquirer adopt a critical orientation, such as planning, monitoring and evaluating one’s inquiry-related actions (Kyza & Edelson, 2003; Loh et al., 1998)
Scaffolding reflective inquiry

Examples of scaffolds that can facilitate reflective inquiry:

**Doing the inquiry**
- Data boxes for storing information
- Easy access to stored and interpreted data
- Automating routine tasks to help students focus on the conceptual aspects of inquiry

**Reflecting on the inquiry**
- Data capture camera to support data evaluation
- Articulation prompts to support planning, monitoring, evaluating
- Annotations to allow free expression of ideas

- Structured online workspace so that students can organize and easily access their work process (Loh et al., 1997).
- Guides and reminders about important investigation steps, in the form of articulation prompts (Quintana et al., 2004).
The STOCHASMOS platform

- Overall goal to scaffold students' data-rich, self-regulated learning in science:
  - Reasoning with data.
  - Augment opportunities for reflection through articulation.
  - Grounding articulation and reflection in the data.
  - Supporting formative and summative assessment by making students’ work visible and traceable.

- Provide reflective inquiry scaffolding for students by:
  - Making thinking visible.
  - Helping focus and organize investigations.
  - Supporting the explanation building process.
  - Providing tools for communicating explanations.
STOCHASMOS

Teachers’ Authoring Environment
STOCHASMOS investigates the role of new technologies in supporting middle-school students’ reflective inquiry practices in science and, in specific, the role of technology-based supports in scaffolding students’ reasoning with scientific data.

We are currently developing a web-based learning environment for supporting students’ scientific reasoning through scientifically authentic investigations with an embedded authoring tool. Teachers and other instructional designers can use this system to design their own web-based investigations with reflective supports.

The research part of the project examines the interactions of the students with the web-based environment following a mixed-methods approach. We are investigating the extent to which the reflective scaffolding supports the construction of students’ scientific explanations using quantitative as well as qualitative methods. The STOCHASMOS environment is available in both the English and the Greek languages.

Announcements

» The first development phase of STOCHASMOS has finished and the system is being piloted in local elementary schools.

» If you are a teacher interested in registering for a free STOCHASMOS account in order to test and use the web-based environment send us an email.
Welcome to STOCHASMOS:

- To create or import a new inquiry environment select an option in the Managing the Learning Environment section. Upon the creation of a new environment, you can choose whether to include a workspace, how to group students, and you will also be able to add or create new template pages.
- To add, delete, or modify your students, visit the section "Manage your students".

### Manage the Learning Environment

<table>
<thead>
<tr>
<th>Title</th>
<th>Description</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ta Φλαμίγκα της Αλυκής Λάρνακας</td>
<td>Οι μαθητές θα διερευνήσουν το θέμα της Φλαμίγκα στην Αλυκή Λάρνακας και ταυτόχρονα μαθήσουν για την ακραυλική της Αλυκής.</td>
<td></td>
</tr>
<tr>
<td>Η Ντετέκτιβ</td>
<td>Η μικρή αυτή διερεύνηση έχει τακτικές σκοπούς: α) την εξοικείωση των μαθητών με το περιβάλλον του ΣΤΟΧΑΣΜΟΥ, β) την εξοικείωση με αρχαιότητες όπως υπαθάνες, στοιχεία για ανάθεση των υπαθάνεων/θεωριών, και πειστικές εξήγησεις.</td>
<td></td>
</tr>
<tr>
<td>flamingo copy</td>
<td>elena</td>
<td></td>
</tr>
<tr>
<td>flamingo copy (no Workspace)</td>
<td>See above</td>
<td></td>
</tr>
<tr>
<td>STOCHASMOS demo</td>
<td>stochasmos demo</td>
<td></td>
</tr>
</tbody>
</table>

[Add]

### Manage your students

This section gives you access to your students' information and enables you to add, delete, or modify the records. [click here to manage students]
Manage project

- **Project**
  From here you can change the following general parameters of the Project: title, description, school, language, and topics. This where you can also activate and de-activate the Inquiry Environment or the students' Work Space.

- **Templates**
  - Here you have access to creating new templates for the students' Work Space or modify existing ones.
  - If you have not deactivated the students' Work Space, you will have to select which templates to use with each inquiry environment (if you have not yet created or imported an inquiry environment, the system will guide you in doing this).
  - You can create as many templates as you want to use in each inquiry environment.

- **Inquiry Environment**
  From here you can create or modify the inquiry environment: add or delete pages and modify the multimedia content of each page.

- **Add Group**
  Use this feature to group existing students, which you previously entered through the "Manage Students" section. Any groups created will only be valid for this inquiry environment.

- **Review**
  From here you can access the work of each group, can give feedback by inserting comments on the students' pages in the Work Space, or give a final score to each group.
Τα Φλαμίγκο της Αλυκής Λάρνακας

ΦΕΒΡΟΥΑΡΙΟΣ 2003
Γεια σας. Ονομάζομαι Κορίκος Παρασκευόπουλος και εργάζομαι στην Υπηρεσία Θησα. Προσπάθησα να συνδέσω το ζώο δημοσιεύσεις και να καθορίσω ένα νέο ρόλο Φλαμίγκο στην οποία ήθελα προσωρινά ένα.

Related Links
- Glossary
- Inquiry Environment Log

Help text
- From here you can create or modify the inquiry environment: add or delete pages and modify the multimedia content of each page.
- To add a new page select "Add". To modify existing pages, first navigate to the page and then select "Article", "Edit".

Back to Authoring tool
STOCHASMOS

Students’ Learning Environment
Τα Φλαμίγκο της Αλυκής Λάρνκας

ΠΛΕΥΡΟΪΑΡΙΟΣ
2003

Γειά σας Ονομάζομαι Ερρίκος Παρασκευόπουλος και εργάζομαι στην Υπηρεσία Θηράς. Πριν από λίγες μέρες πήρα ένα τηλεφωνήμα της βοήθησε έναν άνδρα Φλαμίγκο στη μέση της Αλυκής. Αυτό το γεγονός μπορεί να είναι ένα μυθιστόρημα. Επειδή η σκηνή ήταν εξαιρετικά περίεργη, είχα θέλησα να την αναζητήσω.

Το Τμήμα Αλιείας χρειάζεται να βοηθήσει σας, ο ρόλος σας είναι να συμβουλέψετε το έργο τους. Θα έπρεπε να λύσετε το πρόβλημα του θηρατού των Φλαμίγκο. Έχετε τα στοιχεία που υποστηρίζουν τις υποθέσεις και να καλωσορίσετε την πληροφορία της Εθνικής Αλυκής. Επικοινωνήστε με τους υπεύθυνους για απόψεις και υποστήριξη στο Τμήμα Διήθεση και Αλιεία.
Paste your data here and explain what they mean in the boxes that follow.

Which hypothesis do the data support or disconfirm?
Τοποθετήστε τα δεδομένα σας εδώ και εξηγήστε από κάτω τι σημαίνουν για την υπόθεσή σας:

Προφετεία επί προβλήματος που παράγει τις θεωρίες αλλά δεν δημοσιεύεται στη σελίδα σου.

Διαγραφή

Πολλά είναι τα δεδομένα αυτόματα.

Φύλακα

Προσθήκη...

Bart

newton H

newton 1 H

DEDEOMENA H

DEDEOMENA 1H

DEDEOMENA 2H

ANAFORΑ H

Ποια υπόθεση υποστηρίζουν ή απορρίπτουν τα πιο πάνω δεδομένα:

ΕΚΕΙΝΗ ΤΗΝ ΕΠΟΧΗ ΠΟΥ ΠΕΘΑΝΕΝ ΤΑ ΦΛΑΜΙΚΟ ΣΤΗΝ ΑΛΛΗ ΔΕΝ ΥΠΗΡΧΑΝ ΓΑΡΙΔΕΣ ΔΙΟΤΙ ΔΕΝ ΥΠΗΡΧΑΝ ΜΟΝΟΚΙΤΑΡΑ ΦΥΚΗ ΑΥΤΟ ΕΦΕΚΤΟΝ ΣΤΟ ΟΤΙ ΔΕΝ ΥΠΗΡΧΕ ΑΡΚΕΤΗ ΠΕΡΙΕΚΤΙΚΟΤΗΤΑ ΛΑΛΑΤΟΣ ΣΤΑ ΝΕΡΑ ΤΗΣ ΑΛΛΗ.
Εδώ συνόδευσε τις σημείωσες με τεκμηρίωση από διάφορες πηγές (γραφικές παραστάσεις, σημειωματάρια της Φλορίνκα, κτλ.) που υποστηρίζουν την ύποψή σας για το πώς και γιατί πέθαναν τα Φλορίνκα.

α. αρ. 1 εξ. A
β. αρ. 1εξ. B
γ. αρ. 1εξ. Γ
δ. αρ. 1εξ. Δ

Οι υποθέσεις 263 δεν μες έπαιξαν ευτυχία για πολλά ευχαριστώ και κρόνο.

Προειδοποιήσεις και Αναφορά στη Θεολογία Αριστοτελίου
STOCHASMOS

Research studies
The research program

Goals

- Examine the role of software-based reflective inquiry scaffolding in supporting student inquiry
- What is the role of the reflective inquiry scaffolding in the creation of evidence-based explanations?
- What is the interaction of perceived ability and reflective scaffolding?
Students are reported to have difficulties with both the more general aspects of what constitutes an explanation in science and the domain-specific aspects of understanding ecological concepts. e.g.

- Do not provide evidence in support of their explanations (Sandoval, 2003).
- Students have difficulties in reasoning about causality and noticing indirect relationships (Abrams & Southerland, 2001).
In prior research, we qualitatively examined the discourse and actions of students of higher, medium, and lower academic ability as they worked with the Progress Portfolio (Kyza, 2004).

The scaffolding in the tool supported students’ reflective inquiry conversations about their data.

Most of the lower ability group’s reflective inquiry conversations took place in the context of working with the group.

This led to a hypothesis that such tools may be necessary for lower ability students.
PARTICIPANTS

Pilot enactment
- Three 6th grade classrooms (n=75), same science teacher, half of the dyads with WorkSpace, half of the dyads with PowerPoint.

Second enactment
- Lessons learned from pilot enactment led to the “Detective investigation” for introducing terminology, concepts, inquiry routines, and use of the system.
- Two 6th grade classrooms (n=26, 27), same science teacher, one class with WorkSpace, one with PowerPoint.
- Using the Raven’s standard progressive matrices and a test measuring students’ conceptual understanding of the ecosystem:
  - A two-step cluster analysis showed that students could be grouped in two clusters: those of low learning potential (M=1.43) and those of high learning potential (M=4.33).
  - Chi-square and t-test analyses showed that the two classes were equivalent.
Research Methodology

ACTIVITIES

• Students worked in dyads of high, low, and mixed ability.
• Investigation: “The death of the Flamingos at the Larnaca Salt Lake”.
• Developed using scientific data in collaboration with the Cyprus Fisheries Department.
• Lessons lasted for about 6 weeks and included an initial brainstorming activity, mid-investigation peer-reviews, and final class- and school-wide presentations.

DATA COLLECTION

• Pre and post tests examining students’ conceptual understanding and inquiry skills.
• Videotaped three groups’ interactions with the software, teachers, and peers.
• Logbook of the students’ use of the STOCHASMOS system.
• Each group’s computer-generated artifacts.

ANALYSIS

• Analysis of students’ final explanations.
• Statistical analyses of pre and post tests.
• Case studies of different ability groups as they work with the reflective WorkSpace or with PowerPoint.
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• Pre and post tests on inquiry content and skills.
• Videotaping of three groups’ interactions with the software, teachers, and peers.
• Logbook of the students’ use of the STOCHASMOS system.
• Each group’s computer-generated artifacts in the workspace and in PowerPoint.

ANALYSIS

• Analysis of students’ final explanations.
• Statistical analyses of pre and post tests.
• Case studies of different ability groups as they work with the reflective Work Space or with PowerPoint.
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Φ. Νικόλαος Παπανδρέου
Υπήρεσες Θήρας

*Πλήθος φλαμίγκο στην Αλυκή Λάρνακας*
Σύγκριση παραμέτρων

Ποιες παράμετρους θέλεις να συγκρίνεις; Ποια υπόθεση προσπαθεί να ελέγξεις σχέδια με το θόντο των φλομίνγκο; Κάθε φορά διέλεξε μία από τις εξής κατηγορίες, διέλεξε για ποιες χρονικές θέλεις να συγκρίνεις τις μετρήσεις και για ποιους μήνες και σταθμού.

Γραφική Παράσταση 1

Κατηγορία: Βροχόπτωση
Πίθανος: Αλυκή: Βροχόπτωση (μιλιόμετρα)
Διαλέξεις Μηνιαία
Περίοδος: 01/2000 - 12/2004

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Examples of the students’ explanations

**Group 1, WorkSpace**

Eίδα συμπέτοντας τις σελίδες με τα τράπεζα ακού για διάφορες ειδικές σχέσεις (νερικές περιπτώσεις, κατασκευή των ψεύκτων, κτλ.) που αναφέρονται τις σπάνες που για τον πόλεμο και την εξέλιξη της ψυχοτροπίας.

**Group 2, PowerPoint**

Σφαίρες

Το τρίγωνο το φλαμάγκο και τεθαίνουν: Μήπως είναι οι σφαίρες;

- ΚΥΝΗΓΟΣ: Διάφορες κινήσεις ζήτησαν την απαντήσεις του κυνηγού, στην Αλίκη, αλλά η πίεση τους απαντήθηκαν.

Όταν η στάθηκε τον νερό, ευθεία, τα φλαμάγκα μετακινήθηκαν προς την Φισόδεντρα εκβόλευσαν και όχι επειδή τα αμφιβολία υπάρχουν υπό κανονικές συνθήκες. Επομένως, οι σφαίρες είναι οι ισόγειες στο φλαμάγκο.

**Δημοσίευση**

Εξηγήσεις στο Τράπεζα Αλλάζουν θέσεις και αυτές ως υποθέσεις εξετάζουν και πιστών της απορρίφθηκε. Επειδή, η εξήγησή τας θα άρεσε στην επιστημονική.

Διερευνάμε το ενδιαφέρον το φλαμάγκο με την επιθετική λειτουργία του αντικείμενο ακούγεται και επιτυγχάνεται ως σημείο της απορρίφθηκε. Διερευνάμε το ενδιαφέρον το αντικείμενο ακούγεται και επιτυγχάνεται ως σημείο της απορρίφθηκε.
### Explanations coding scheme

- **Modified Toulmin’s argumentation scheme**
- **Based on the expert criterion map**

<table>
<thead>
<tr>
<th>Level</th>
<th>Main explanation</th>
<th>Clarity</th>
<th>Support evidence</th>
<th>Refuted explanations</th>
<th>Reasoning for rejecting alternative explanations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The group has not provided any claim answering the problem they were asked to solve.</td>
<td>The group has not provided any clear claim.</td>
<td>The group has not provided any evidence to support their claim.</td>
<td>The group has explained their reasoning as to why they refused.</td>
<td>Some of the claims may be missing or not explained adequately.</td>
</tr>
<tr>
<td>1</td>
<td>The group has no one definite claim and may e.g. present two claims.</td>
<td>The group has not provided any clear claim.</td>
<td>The group has provided evidence for some or for all of the alternative explanations they have rejected.</td>
<td>The group has explained their reasoning as to why they refused.</td>
<td>Some of the claims may be missing or not explained adequately.</td>
</tr>
<tr>
<td>2</td>
<td>The group has provided a claim stating an answer to the problem they were asked to solve.</td>
<td>Students provide an ecosystem-related mechanism for how the flamingos died.</td>
<td>Students provide an ecosystem-related mechanism for how the flamingos died.</td>
<td>Students provided an ecosystem explanation, where they explain the key ideas of how the interdependence of biotic and abiotic factors led to the death of some of the flamingos. Explanation cannot be given full marks because it may lack important comparisons such as reference to baseline data from previous and future years.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Students provide an ecosystem-related mechanism for how the flamingos died, in which they explicitly mention relationships between exogenous environmental and endogenous biological factors of the ecosystem as they are related to the flamingos. Moreover, the mechanism is not adequately explained: for instance, two factors (biotic or abiotic, e.g. flamingo, rainfall) may be linked, but intermediate links may be ignored or not adequately explained (rainfall, water height, brine shrimps, flamingo). Some false reasoning may also exist.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Full marks - same as #4, but explanation refers to baseline data, as well.</td>
<td>Students provide an ecosystem-related mechanism for how the flamingos died.</td>
<td>Students provided an ecosystem explanation, where they explain the key ideas of how the interdependence of biotic and abiotic factors led to the death of some of the flamingos. Explanation cannot be given full marks because it may lack important comparisons such as reference to baseline data from previous and future years.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Students provided an ecosystem-related mechanism for how the flamingos died, in which they explicitly mention relationships between exogenous environmental and endogenous biological factors of the ecosystem as they are related to the flamingos. Moreover, the mechanism is not adequately explained: for instance, two factors (biotic or abiotic, e.g. flamingo, rainfall) may be linked, but intermediate links may be ignored or not adequately explained (rainfall, water height, brine shrimps, flamingo). Some false reasoning may also exist.</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Reasoning**
- The group does not provide an explanation of the claim they have provided or provides an explanation that is not related to the claim put forth.

**Supporting evidence**
- The group has not provided any evidence to support their claim as to why the flamingos die or may cite as evidence background data.

**Refuted explanations**
- The group has explained their reasoning as to why they refused.

**Reasoning for rejecting alternative explanations**
- The group has provided evidence in support of all of their refuted explanations. There is no contradictory or irrelevant evidence cited, and the evidence is all appropriate. The group has explained the connection between the alternative explanations and the evidence cited. However, they have not provided adequate evidence for all claims stated, or the evidence may not be sufficient or well-justified to
**Results**

- An analysis of the students’ pre-post measurements indicated a statistically significant difference for the workspace class, $t(26)=-4.492$, $p<.001$, and for the PowerPoint class $t(25)=-3.455$, $p<.005$.

- Cohen’s $d$ was 0.75, indicating a medium to large effect size of the intervention.

- Mean total explanation score was higher for the WorkSpace class, $M=11.2$, vs. $M=8.23$ for the PowerPoint class.
What components did they address?

<table>
<thead>
<tr>
<th>Ability</th>
<th>Workspace</th>
<th>Powerpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HH</td>
<td>HL</td>
</tr>
<tr>
<td>Number of groups</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Main explanation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Claim</td>
<td>5 (100%)</td>
<td>5 (100%)</td>
</tr>
<tr>
<td>Reasoning</td>
<td>5 (100%)</td>
<td>5 (100%)</td>
</tr>
<tr>
<td>Cited evidence</td>
<td>4 (80%)</td>
<td>5 (100%)</td>
</tr>
<tr>
<td>Alternative explanations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Listed refuted explanations</td>
<td>5 (100%)</td>
<td>4 (80%)</td>
</tr>
<tr>
<td>Provided a reason for the refuting</td>
<td>5 (100%)</td>
<td>4 (80%)</td>
</tr>
<tr>
<td>Cited evidence</td>
<td>4 (80%)</td>
<td>4 (80%)</td>
</tr>
</tbody>
</table>
Results

- To examine the effect of the type of reflective scaffolding and ability grouping we used the Kruskal Wallis test.
- The analysis showed **no difference** between the three ability groupings in the workspace class, $x^2(2)=2.382$, $p>.05$.
- The analysis showed **differences** between the groups in the PowerPoint class, $x^2(2)=6.109$, $p<.05$.
  - Subsequent Mann Whitney U tests showed a significant difference between the groups in the HH and LL groupings ($U=.00$, $p<.05$), the HL and LL groupings ($U=1$, $p<.05$) but not between the HH and HL groupings ($U=4$, $p>.05$).
Results

WorkSpace

- Findings indicate that there was no statistically significant difference between HH, HL, and LL groups. This suggests that the different scaffolding may have helped the lower ability students bridge the gap between them and students of higher academic ability.

PowerPoint

- Findings indicate that the HH and HL groups outperformed the homogenous LL groups, but that there were no statistically significant differences between the homogenous high and mixed high-low ability groups.
- There were still differences between lower and higher ability groups.
Thank you. Comments?

c.p.constantinou@ucy.ac.cy

For more information, please visit:
http://www.stochasmos.org