# Modeling Context Effects in Science Learning: The CLASH Model

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**Abstract.** In science learning, context is an important dimension of any scientific object or phenomenon, and context-dependent variations prove to be as critical for a deep understanding as are abstract concepts, laws or rules. Our hypothesis is that a context gap can be illuminating to highlight the respective general-particular aspects of an object or phenomenon. Furthermore, provoking a perturbation during the learning process to obtain the emergence of such an event could be a productive tutoring strategy. We introduce the emergence of context effects as a problem space, to be modeled in the system. We propose a model of the contextual dimension, associated with an analytical view of its modeling, based on a metaphor in physics.

**Keywords:** science education, context effect, model, context, learning scenario.

## 1 Introduction

A context is defined as a set of objects and events that surround an entity situated in the center and that have structural and functional links with the center. In biology, the context of an animal consists of biotic and abiotic environmental conditions. In science learning, the context of the learner consists of previous knowledge and skills, conceptual models, metacognitive capability, motivation, location and spatial and social environments. A *context effect* is an event that is produced by tension between two contexts. This event is challenging for learners, particularly for their existing mental models. Suddenly, these good old or not so old representations they have no longer account for the new context, and the learners are challenged to proceed to a conceptual change or to accommodate multiple representations. From a scientific viewpoint, each context effect can be isolated to allow for the study, control and manipulation thereof. However, this would mean to study it out of its context, similar to *in vitro* investigations. From a more naturalistic viewpoint, we wish to study the process of the emergence of these events, and consequently the position of an event either on a timeline or in space. We also wish to analyze the correlations among a set of events. Measuring the scientific objects in terms of levels of contextuality might

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bring valuable information for the understanding and interpretation of the object of study. In this paper, we introduce several issues : the notion of *context effect*, the CLASH Model with the Maz-Calculator, two learning scenarios, and the architecture of a context-aware tutoring system with an authoring service.

## 2 Context Effects in Science Learning

Science teaching is designed to take into account observations of what is real, as well as experiments. *Authentic* teaching aims to construct students' conceptions on the basis of real situations in both the laboratory [1] and the field for the naturalistic dimensions of the sciences. *Authentic* approaches based on contexts [2] fit into this vein and entail investigations based on the study of environments familiar to the students. The gaps between the contexts of the various actors can lead to misunderstandings, and there are times, in particular when these gaps are significant and when the teaching situation lends itself thereto, that an "event" emerges that renders the gaps explicit. These incidents are called "context effects"[3]. The model we propose here aims to facilitate the identification and description of this phenomenon. Our model possesses a predictive value in that by implementing the parameters of the contexts studied, it indicates the likelihood of the emergence of a context effect.

The objective is to highlight the comparison of learners' conceptions in response to observation results that are different but linked to a single concept,. In biology and geology, the contexts are an integral part of the concepts studied. The concept may be considered as a straight line of which the contexts would be the segments. Situating this context amounts to defining its specificity and representability. The comparison of two unique contexts may be carried out in two ways: 1) through resemblance, which makes it possible in particular to specify the level of generalization of the characters observed to all or a part of the concept; and 2) through dissemblance, which is useful for specifying limitations, singularities and false interpretations.

## 3 Modeling the Context Effect: The CLASH Model

Context effects are modeled based on a metaphor taken from signal processing (Fig.1). In the case of a multi-frequency signal, which corresponds to a sinusoidal curve with various wavelengths, the law selected by the observer to describe the signal may be different in comparison with his observation thereof. According to the observation scale, he is likely to concentrate his analysis on the wavelength that is the most visible at this scale. Much smaller and much larger variations in wavelength will not be perceived, even though they affect the signal in its entirety. Another parameter, the sample size, influences the effect of the various wavelengths in the general representation. When we attempt to describe the evolution of a measured value by comparing it to a theoretical value, indicators such as the Root Mean Square (RMS) are classically used to quantify the error. It is therefore a question of minimizing the RMS and increasing precision in the course of the process.

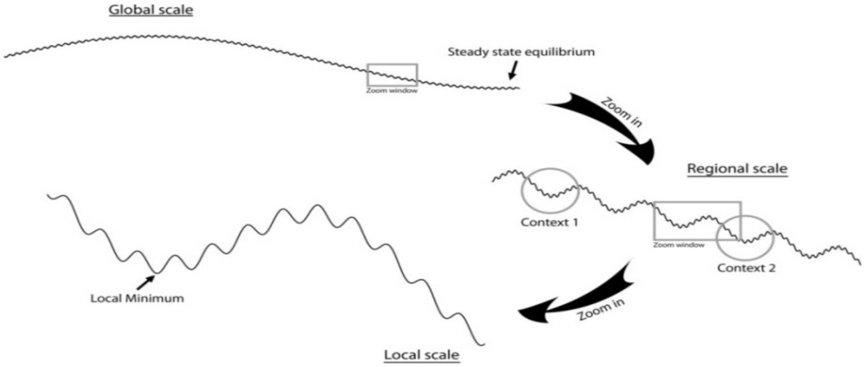


**Fig. 1.** The Context Effect Model: CLASH

If the observation scale or the sample size is inappropriate, the minimum RMS value might not correspond to the best overall solution. In such a case, the solution is likely to be specific but inexact. This is known as a local minimum. To avoid this possibility, the scales of analysis have to be varied and the sample size increased. Unfortunately, it is not always possible to adjust the scale (technical constraints) or to have a comprehensive view (outcroppings available in geology, for example). In this case, it is best to make observations of the same type but in different contexts through context gap jump-over. By making observations of the same system in different contexts, it is possible to understand how the system evolves (in space, time, society, etc.).

Derived from this model is the *Maz-Calculator*, which indicates the frequency of appearance of context effects based on the gaps of different parameters in two educational contexts. Each context is described in terms of the parameters linked to the teaching objectives, and applying the *Maz-Calculator* to each of these parameters allows it to provide an overall indicator for the contexts selected on the basis of the gaps of each of the parameters.

## 4 Two Learning Scenarios: *Gounouy* and *Magma*

In order to test our hypothesis on the benefits of context effects, we designed two learning scenarios, one in biology for secondary school learners, the other in geology for university students. Both share the same structure and are based on collaborative learning, direct observation, lab investigation, information exchange, expertise sharing, collaborative reflection and discussions. Both involve two groups of students, one in Guadeloupe, a tropical area, and one in Quebec, Canada. The *Gounouy* scenario leads the students to make fine-grained observations and measurements of the local common frog. The smallest one in the world, the Caribbean frog, is called whistling (*Euleutherodactylus sp.*); in Quebec, the largest one in North America is called bullfrog (*Lithobates catesbeianus*). The scenario is designed in such a way that the learners are stimulated by the contrasting results of their observations and the common ground of the biological concepts. In the *Magma* scenario, the object of study is magmatism; the students are required to compare some of the oldest rocks (Quebec) and the most recent rocks (Caribbean) and to explain the differences based on geophysical concepts. The measurements performed by the learners are quantified to allow for calculation. Each parameter used can be filled either qualitatively or quantitatively [4]. For the *Gounouy* project, the parameters are: frog call, morphologic and taxonomy, the environment, relationship with humans, and developmental nutrition. Parameters used for magma can be classified into different scales: Geochemistry (%SiO2, %MgO FeO, spectrum REE) Microscopy (presence of minerals, % Quartz, % Plagioclase) snip (texture, mineralogical composition, vacuole, deformation) landscape (hexagonal prismation, relative chronology, particular landscape elements) and regional (cartography, variability, age, seismicity)

For these two scenarios, a simple learning environment is being implemented through a Learning Management System*, Moodle*, to provide access to documents and services (communication, sharing), as well as to capture the data needed to test our hypothesis. In parallel, the modeling of a context-aware tutoring system is underway.

## 5 The Building Blocks of a System

Several components can provide a structure for the modeling of a context-aware tutoring system: domain, scales, competencies, and context of the animal, the learner and the teacher.

The architecture of a context-aware tutoring system with its‘ authoring services’ is proposed as illustrated in Fig.2. One key issue in developing successful learning environments or tutoring systems is to provide the system with a valid learning scenario. In this authoring system, the Maz-Calculator is a key service, used not only for estimating the context effect frequency but also for highlighting the context parameters that are involved. The author could then use this information to revise the learning scenario. She can be assisted in this adaptation task using CEM tools combined with three scenario management tools (CAS-Edit, CAS-Viz and CAS-Sim) as described in Fig. 2. In this way, it would be possible to iteratively play with the context parameters provided by the Maz-Calculator and adjust the scenario accordingly. The resulting scenario is stored in the CSLS database. As shown in Fig. 2, the Intelligent Tutoring System itself (CAITS) comprises three main components. It is connected to the contexts pool in three ways. The first connection is implemented by the interaction between the Maz-Calculator and the CSDM; this connection makes it possible to provide the ITS with context effects information which will drive the domain model behavior. The second connection is a direct link to the contexts pool which gives access to other contextual parameters to be considered during learners/system interactions; this includes contextual information about the learners’ profiles, as well as instructional/learning strategies. The third connection is done through the CSLC database allowing the CAITS to load relevant instructional scenarios that will drive the tutor behavior.

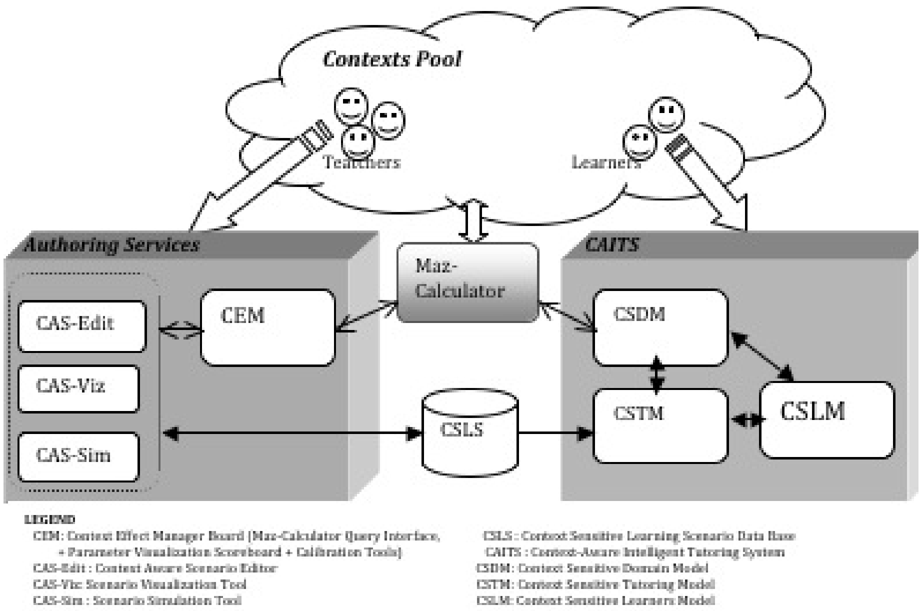


**Fig. 2.** CAITS Architecture with Its Authoring Services

## 6 Future Work

Future work consists of: 1) implementing and testing the model; 2) experimenting the scenario *in situ,* in schools and in universities; and 3) designing a context-aware tutoring system with an ‘authoring service’. Implementation and testing of the model is under development. The research methodology is Design-Based Research (DBR) [5]. The design of a context-aware tutoring system with an ‘authoring service‘ will be further detailed. Intelligent tutoring systems for science learning have been evolving along the modeling of the student, the domain knowledge and the tutoring knowledge, rarely taking context into account [6]. Context modeling for mobile learning environments focuses mostly on localization and adaptation to rapid changes of user localization. Our work is original and innovative in that it integrates context awareness and provides the author with a scientific foundation for designing an instructional scenario.

## 7 Conclusion

The CLASH Model makes it possible to validate experimental hypotheses on the emergence of context effects in science teaching both in secondary school and at university. Adapting this model to research on similar teaching at different levels or of different themes appears to be possible and would be particularly useful as an aide to the choice of contexts taken up by the teacher. Measuring the gaps between context effects could also be used in the development of a context-aware digital learning environment.

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