

Creating a Visual Representation of Expert Strategies to Inform the Design of Digital Tools for Citizen Science

Jessica Roberts, Carnegie Mellon University, jarobert@andrew.cmu.edu

Kevin Crowley, University of Pittsburgh, crowleyk@pitt.edu

Marti Louw, Carnegie Mellon University, mrlouw@andrew.cmu.edu

Abstract: Tools supporting citizen scientists in learning complex observational tasks like taxonomic identification scaffold expert practice by specifically attending to the aspects of expertise relevant to citizen science. This poster describes our process for developing a visual representation that characterizes observational practices and moves entomologists make when identifying unknown organisms. We outline how this work is guiding the design of a digital teaching collection of freshwater insects, macroinvertebrates.org, to support citizen based water quality assessment activities.

Introduction

Citizen science volunteers engaging in complex data collection tasks such as aquatic macroinvertebrate identification (ID) for water quality monitoring require a vernacular understanding and associated set of scientific skills to generate reliable and useful data (Snyder et al., 2017). Volunteers often “fail to see” and have difficulty recovering from errors in taxonomic work (Nerbonne and Vondracek, 2003). When volunteers are unable to reliably generate accurate data, it can lead to a “taxonomic bottleneck” that limits the impact and effectiveness of some citizen science projects. We are developing an innovative digital teaching collection based on explorable, high-resolution annotated images with supplemental multimedia in order to support the development of citizen science skills such as scientific forms of noticing and associated observational practices.

A crucial step in designing this online learning platform is characterizing observational expertise in entomology in order to know what observational practices need to be supported. To inform this effort, we developed a novel visual representation of expert processes depicting how various forms of scientific knowledge and visual practices are put into action to make an accurate identification. We hypothesize that a visually informative representation of observational expertise is a productive way to elucidate key strategies for observational fluency and highlight the varied use of scientific inscriptions and resources that need to be supported and incorporated into the design of online learning tools and systems.

Methods

We conducted contextual inquiry think-aloud interviews with eight experts in entomology, ranging from early career researchers to professional taxonomists with 20-30 years of experience in aquatic macroinvertebrate ID. When feasible, interviews were conducted at the experts’ work sites to ensure access to the materials and tools they would typically use when conducting an ID. The researcher provided participants with three specimens to identify to the lowest taxonomic level they felt comfortable (typically genus), asking them to describe their process and prompting them with clarifying questions as necessary. Transcriptions were made from audio recordings, and videos and photographs of the working environment were taken.

Analysis and Findings

We sought to characterize how scientific expertise and associated practices shape the ID process. We first coded and distilled a subset of the interviews into a step-by-step listing of the moves made during each ID. A *move* is defined as a significant action or recognizable step that drives the identification process toward naming the specimen at the order, family and genus level. We next created a matrix representation matching the information gathered during the ID process with the resources used to generate that information. We define *resources* as any tangible tool (e.g. microscope), external source (e.g. dichotomous key, Internet search), or observational practice (e.g. manipulating specimens or lighting to optimize viewing). These initial representations helped clarify aspects of expert practice but were not yet a graphically succinct externalization of expertise that could be used to inform platform design. We therefore created a new representation, which we call Shared Externalization of Expertise (SEE) because of its potential for facilitating communication across stakeholders.

The SEE diagram (Figure 1a) uses an up-down metaphor frequently invoked in taxonomic identification that refers to progressive taxon levels as “lower,” e.g. “taking it down to genus” and displays steps taken in the identification process as descending. If the taxonomist were using the same strategy (e.g. directly matching the characters listed in a couplet to features of the specimen) throughout the ID, the diagram would

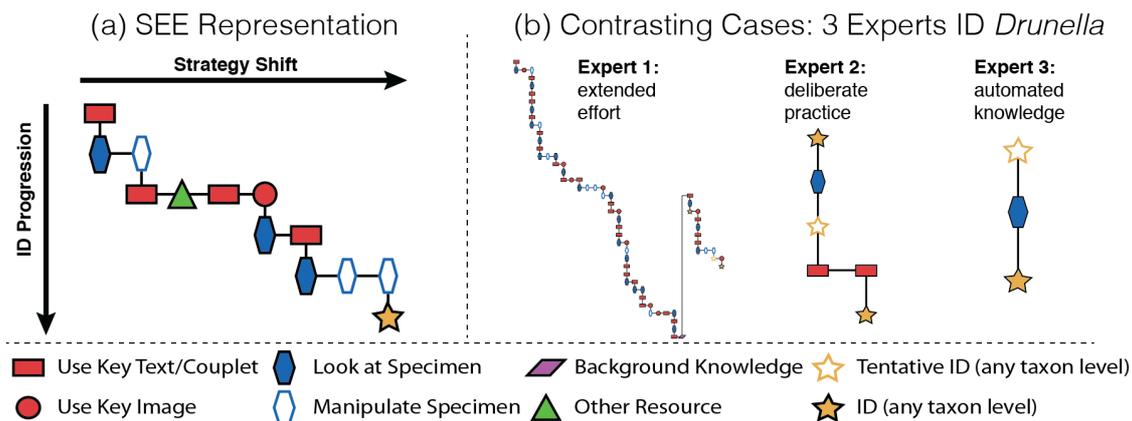


Figure 1. An example SEE diagram (a), and diagrams of moves by three experts ID process for *Drunella* (b).

form a straight line down. However, experts tend to use multiple strategies during the identification process to make a judgment (e.g. consulting an additional text or image if the initial resource is insufficient), and these strategy shifts are displayed as horizontal movements along the x-axis.

Such horizontal moves are manifestations of expertise. In a complex activity like taxonomic ID, knowing how to navigate uncertainties is crucial for success, yet non-experts facing uncertainty are less likely to have the resources and knowledge to work around difficulties (i.e. shift strategies). SEE diagrams show how experts strategically address uncertainties, for example in our study as several subjects were asked to separately identify the same specimen (Figure 1b). Expert 1 had difficulty confirming characters and had to adjust after initially going down the wrong path in the key. By contrast, Expert 2 easily confirmed diagnostic characters and quickly navigated the key, and Expert 3 confirmed the ID by looking for known diagnostic characters without the aid of any text. Experts 2 and 3 didn't demonstrate uncertainty with this specimen, while Expert 1 struggled yet was still able to work around challenges. Our digital tool is not meant to transform novices into Expert 3, but to support them in persevering through a process like Expert 1's by providing appropriate resources and support.

DISCUSSION

Expert taxonomists have extensive resources for identification, including their own knowledge and experience, a variety of keys and guides, access to informed colleagues, and an understanding of the “tricks” for recognizing diagnostic characters. Amateur citizen scientists have a much more limited toolbox, meaning that when their primary resource (e.g. a regional key) doesn't contain sufficient guidance, they have few places to turn for help. Our platform, macroinvertebrates.org, is designed as a visual guide to supplement the wide variety of primary ID resources already in use by citizen science groups and to support multiple audiences ranging from novice volunteers to trainers. Our key challenge is not to present all the entomological knowledge our users *could* need, but to present the right information in a way users can strategically access it.

The process of creating these representations has informed multiple aspects of our ongoing design based learning research. Certain strategy shifts recurred across multiple SEE diagrams, indicating their value to experts and suggesting they should be prioritized in our design. These diagrammatic representations have also been used in design meetings to evaluate navigation, interaction, and interface design choices in the expansion and redesign our platform. The representations of expert practice have served to concretize the open-ended design space from the general need to support volunteers into specific actionable scaffolds and information design solutions we can provide to our users to make it easier for them to learn to see with an expert eye.

References

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