LucID: A Multimedia Educational Tool for Identification and Diagnostics

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Abstract

LucID is a multimedia expert system designed specifically to help users make a correct identification of a biological specimen or to correctly diagnose a particular problem. The program comes in two parts, a builder used in the creation of keys, and a player that enables the user to identify specimens or to diagnose a problem using the key. A major feature of *LucID* is its ease of use. This and other features of *LucID* are described and a number of examples are provided of how *LucID* is being used for identification and diagnosis, and to access information relevant to the item that is keyed-out. The role *LucID* is playing in recent decision support and training systems is outlined. Future possibilities for *LucID* are explored, including the role it can play in distance education, in training users to make accurate observations, and in teaching the logical processes involved in creating keys.

Introduction

Biologists, conservation specialists, quarantine professionals, and those involved in biodiversity and environmental impact assessment rely on the correct identification of organisms to analyse problems. In many professions, identification and diagnostic skills are 'out-sourced'. To identify an unknown insect, for example, the specimen is often sent to a specialist. However, the increasing shortage and/or cost of providing this specialist expertise means that this course of action is often not feasible, posing a major impediment to improved resource management. At a time when biodiversity professionals are in increasing demand and accelerated identification processes are needed, taxonomy is being squeezed out of the university curriculum through competition for diminishing resources with the new technologies of biology. Thus, for practical resource management as well as for the classroom, there is an increasing need for easy to use identification and diagnostic tools.

Interactive, multimedia keys are one way of resolving this taxonomic crisis. They provide a mechanism for transferring taxonomic expertise into a form that is easily accessed and employed by non-taxonomists. *LucID* is a multimedia identification and training tool, developed at The University of Queensland. It has become popular because of its ease of use - both in creating guides to identification and as a source of information. Originally designed for taxonomic identification, *LucID* is also being used for much broader diagnostic purposes. Collaboration of

experts to produce *LucID* keys is proving to be an exciting and cost effective way of consolidating dispersed knowledge bases.

This paper consists of four sections:

- a description of the *LucID* system, consisting of the key builder and the key player;
- examples of *LucID* keys to illustrate the various ways in which *LucID* has been used to build identification and diagnostic keys across a range of disciplines;
- the role of *LucID* in the university; and
- the potential for *LucID* in the future, as a multilingual, CD-ROM/Internet product.

The *LucID* system

LucID is a research, educational and decision support tool that enables the user to identify specimens, such as biological taxa, or to diagnose problems, such as sick crops or sick patients. The *LucID* system consists of a Builder and a Player. The Builder allows teachers, lecturers, taxonomists or decision support developers to build and modify identification or diagnostic keys to meet the particular requirements of specific users. The Player allows users to browse *LucID* keys, which can incorporate text, images, video, and sound to help the user select those taxonomic and diagnostic characteristics which best describe the particular case being investigated. As the user selects character states, those taxa or causes of the problem to which these character states do not apply are rejected, reducing the list of possible taxa or causes. Once the specimen has been identified to a particular taxon or a diagnosis made, *LucID* then provides multimedia fact sheets, sub-keys, or links to web sites for further information or recommendations.

For the last 200 years, dichotomous keys provided the main way in which users could access expert knowledge in order to identify specimens. These paper-based keys consist of a series of questions about characters, the user starting with the first multiple choice question. The character state chosen from this multiple choice directs the user to the next question to be addressed. In this way, the user moves up a branched tree to finally reach a specific taxon at the tip of a branch.

As well as being time consuming and often tedious, dichotomous keys do not offer the user a choice in the sequence of characters investigated. This can be a major problem if the user is unable to answer a specific question. By contrast, open access keys, such as *LucID*, allow the user to decide in which order to work through the characters in the key, depending on the specimen being investigated and the user's ability to distinguish between different character states. The addition of an 'expert route' facility to *LucID*, which guides the user along a sequence of characters an expert would recommend, provides the option of using *LucID* both as a dichotomous key and as an open access key.

The following screen dumps illustrate how the *LucID* Player operates. The first screen shot is taken from a key to urban pests. It shows the four *LucID* windows that provide the main interface between the user and the key. In this particular key, 35 characters with multiple states are available to choose from to identify 27 urban pest taxa.
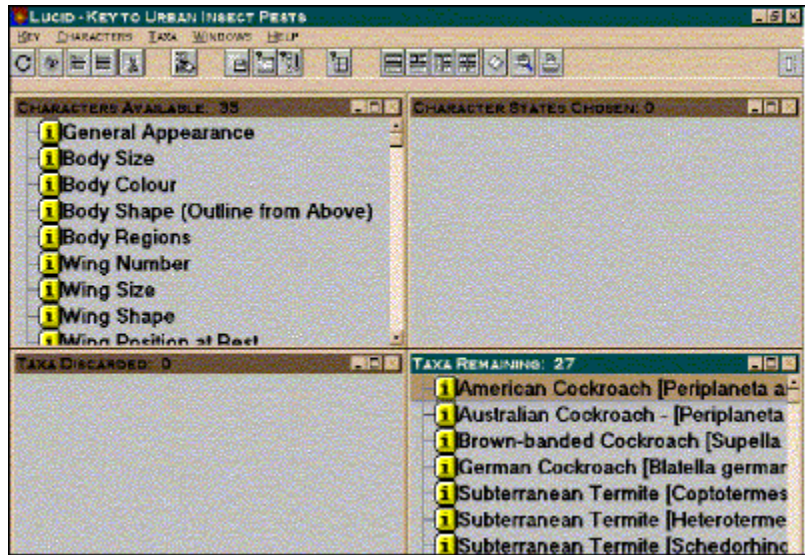
Figure 1. *LucID* **Player**

LucID provides a full multimedia capability that allows the user to look at images or videos to help in determining which character state is most appropriate for the particular specimen to be identified. In the example below, the user has clicked on the information box to the left of the character state 'bug-like' and an image of that character state has appeared.
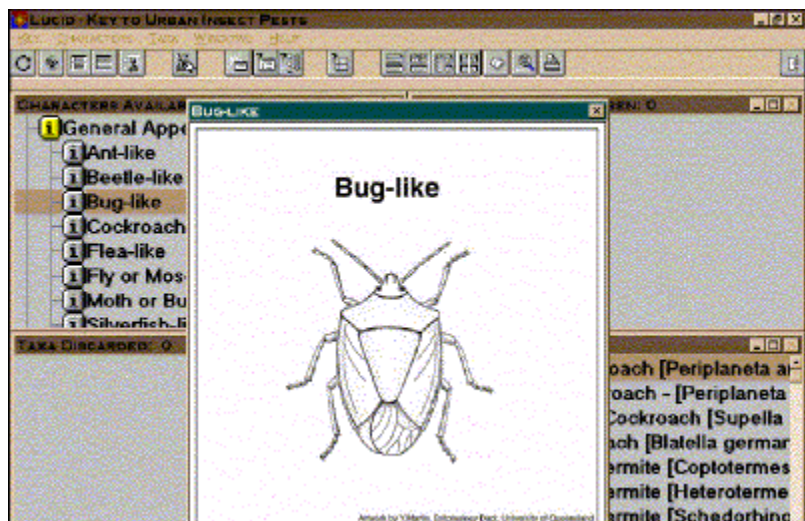

Figure 2. Image of selected character state

More detailed character states can be viewed - first as 'thumb-nails' which can then be zoomed up to a full image - in this case, "Wing position at rest: Wings held at right angle to body".
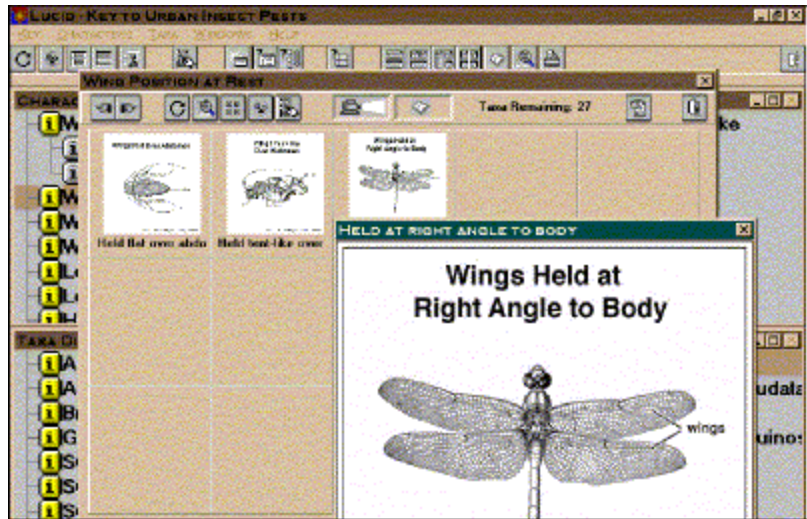
Figure 3. More detailed character state

In the final screen shot, the selection of four character states have led to the identification of a particular taxon - the subterranean termite. By clicking on the information box next to the taxon name, text, images, video and other multimedia can be accessed, providing further information about that termite.
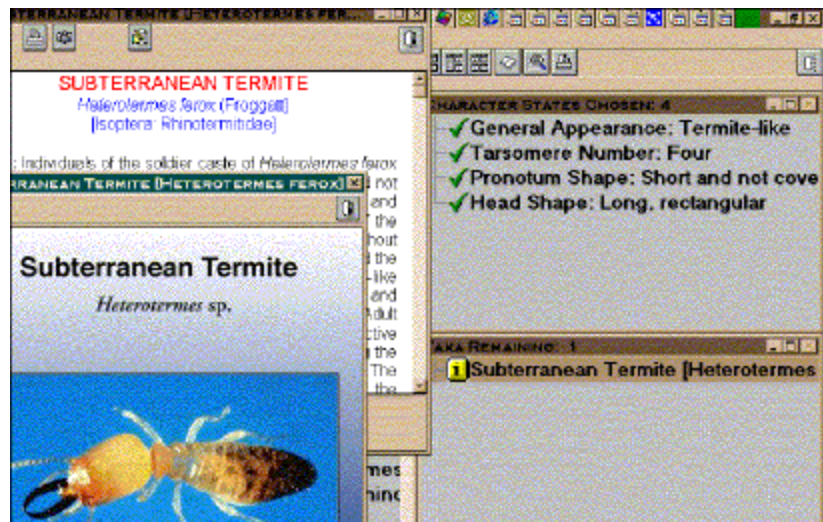

Figure 4. Identification of a particular taxon

LucID keys can be built in various languages and use terminology familiar to the user, allowing the package to be used internationally, across a wide range of abilities. Potential users range from biologists, geologists, agriculturalists and veterinary and medical scientists to university and high school students and the general public. For more information about *LucID* and for an up-to-date list of *LucID* keys, visit http://www.lucidcentral.com/.

Examples of *LucID* keys

The following three keys illustrate how *LucID* is being used in different disciplines for different purposes:

A key to Australian Aquatic Invertebrates (Version 2)

This key, developed by Ben Gunn, John Trueman, Sophia Dimitriadis and Peter Cranston, provides a series of keys to help those with little background in invertebrate taxonomy to identify fresh water macro-invertebrates. This key is particularly relevant for environmental science students who use invertebrate diversity as a measure of water quality. On opening the CD-ROM, the first key the user encounters is the 'top' key, which provides assistance in determining to which major group the specimen belongs - such as sponges, jellyfish, roundworms, leeches, crustaceans and so on. The user can obtain information at this level of identification or, in half the cases, can proceed to a more detailed identification by pulling up a sub-key to that specific group: over 30 sub-keys are available. Throughout the identification process the user is helped by over 1500 images to illustrate possible character states and glossaries that explain technical aspects.

Diagnostic key for mouth ulcers

Laurie Walsh and Alex Forrest of the School of Dentistry at The University of Queensland have developed this key for use by undergraduate students. Their aim is to demonstrate diagnostic pattern recognition, which is the major approach used by experienced clinicians. The key addresses the problem of diagnosing 29 different conditions which can appear as ulcers in the mouth. These range from common conditions, which affect a large proportion of the population, to rare lesions. Eight characters are used in the key in a sequence that a clinician would apply for gaining further detail about the patient, their condition, and the lesion itself. This emphasises the need for a systematic approach in the diagnostic process. The eight characters are:

- history (e.g. first presentation or recurrent presentation);
- systemic signs/symptoms (e.g. fever, malaise, diarrhoea, night sweats);
- local signs/symptoms (e.g. swelling, lymphadenopathy);
- pain - in terms of severity;
- precipitating factors (e.g. medication usage, trauma, stress, corrosive chemical exposure, dental treatment, anti-cancer chemotherapy, radiation, immune suppression, malnutrition);
- number of ulcers;
- site of ulcer(s) (14 different regions of the oral cavity); and
- ulcer border (e.g. undermined, indurated, pseudomembrane).

An important feature of *LucID* is that it allows the key builder to use a 'commonly mistaken' score, when developing the key, to allow for difficulties the user may have in correctly determining character states. This may mean that those using the *LucID* key may not be able to key out a single final diagnosis but be left with a few possible conditions, which will need to be discriminated by histology, serology or other means.

The third example illustrates that, although *LucID* keys can be developed as information products in their own right, they are also being used as a component in more general training and decision support products.

Urban pest control

A commercial CD-ROM product has recently been developed at The University of Queensland to provide training and decision support for urban pest control operators in Australia. The CD-ROM includes a number of modules that address the main issues determining the operator's competency, such as pest monitoring, pest identification and choosing the most appropriate pest control measure. As well as video clips, fact sheets and links to the web sites of pesticide manufacturers and suppliers, the CD-ROM includes four *LucID* keys to help the user diagnose timber damage problems and identify stored product and other urban pests. Keys and relevant modules from the CD-ROM are being adapted to enhance an urban entomology undergraduate subject, which is offered to remote students via the Web, CD-ROM and printed notes.

The role of *LucID* in the university

A number of *LucID* keys already developed have wide suitability for use in undergraduate and postgraduate teaching. The list of keys below gives an indication of the range of topics covered:

- Eucalyptus of South Eastern Australia;
- Families of Flowering Plants of Australia;
- Wattles of the Kalanie Region;
- Identification guides to mites and thrips;
- Insects found in cotton;
- Staghorn Corals of the World;
- Mosquitoes of Torres Strait; and
- 80 Common Minerals.

At present, three universities (The University of Queensland, The University of Sydney and The University of Adelaide) are participating in a *LucID*-based CUTSD (Committee for University Teaching and Staff Development) funded project called 'BioED: Biodiversity and education in an interactive, multimedia environment'. BioED will be a structured CD-ROM package of *LucID* keys and taxonomic information on major groups of organisms (bacteria, Protozoa, arthropods, plants and frogs). The project has three goals:

1. to develop new identification tools (*LucID* keys) for CD-ROM and the Internet to enable us to teach organismal biology subjects more effectively;
2. to provide a tool for restructuring and rejuvenating laboratory sessions concerned with the identification and classification of organisms; and
3. to stimulate a chain-reaction in other tertiary institutions within Australia with new and additional taxonomic keys that are not only easier to use but are educationally superior to traditional keys.

We believe *LucID* has the potential to reform teaching methodology in this important area of the biological sciences through students browsing developed keys and by them developing their own keys. For instance, the *LucID* Builder has been utilised effectively in advanced student projects to teach the principles of key development. Students are not only required to observe, understand and often draw the important characters of the group involved, but also learn additional skills such as electronic image manipulation and how to incorporate video and audio components into their keys.

Future potential for *LucID*

LucID is the product of five years research and development, involving participants from a number of research, university and industry organisations in Australia and elsewhere. For instance, collaboration with colleagues in the Asia-Pacific region has led to the development of versions of the *LucID* Player in languages other than English, including Mandarin, Bahasa Indonesian and Vietnamese. Development of players for other languages will be an important priority in the future.

The *LucID* project is ongoing and, in response to users' requests, we have recently developed and are currently beta-testing a web-based version of *LucID*, which allows users to access keys from any web site. This new version, which can be used for CD-ROM as well as web-based keys, has a number of added features, such as supporting HTML and offering a wide range of image formats. Clearly, *LucID* has broad potential for use in distance education by providing exciting, interactive and diverse ways to present large amounts of taxonomic and diagnostic information.

Acknowledgements

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