

Perspectives on presentation and pedagogy in aid of bioinformatics education

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Submitted: 2nd May 2010; Received (in revised form): 29th July 2010

Abstract

Using live presentation to communicate the interdisciplinary and abstract content of bioinformatics to its educationally diverse studentship is a sizeable challenge. This review collects a number of perspectives on multimedia presentation, visual communication and pedagogy. The aim is to encourage educators to reflect on the great potential of live presentation in facilitating bioinformatics education.

Keywords: *presentation; bioinformatics; lecture; teaching; learning*

INTRODUCTION

Creating the infrastructure to teach bioinformatics has restructured educational institutes the world over [1–4]. The scale of these efforts is such that it is easy to overlook the significant demands of the more personal dimensions of teaching and learning in this rapidly evolving field. The lecture, tutorial, and seminar persist as foci of academic development. Here, educators and students have a prime opportunity to engage one another and, on a human level, exchange and reinforce not only domain knowledge, but its meaning, context and value. Across these settings, it is common and often expected that presenters use multimedia presentation technology—typically ‘slideware’ such as Microsoft’s Power Point® or Apple’s Keynote®. The benefit of such technologies in the pedagogical arena has been widely debated [5–8]; nevertheless, their use has become a staple feature of contemporary academic presentations. The corollary is simple: presenters must integrate the use of slideware and multimedia with the educational strategies suited to their domain. Sadly, communicative interference is widespread due to the imposition of the medium’s ‘cognitive style’ on content [9]. The demands bioinformatics education places upon its diverse

studentship leave no room for such interference. Bioinformatics educators may thus benefit from re-evaluating the role of presentation in instruction.

This review gathers diverse perspectives which, the author believes, promote innovative teaching and learning strategies supported by live presentation and slideware. Although generally pertinent, these views are rarely specific to bioinformatics education; however, the author attempts to provide several domain-specific illustrations of their application. The material is assembled in the spirit of Mayer’s 2003 rejection of technology-centric approaches to instruction with multimedia, emphasising the learner’s cognitive processing over the medium of delivery in constructing knowledge [10]. Hence, this review discusses the integration of modern pedagogy and presentation rather than providing a manual for presentation creation and delivery (available elsewhere [9, 11–13]).

SETTING THE STAGE FOR THE ACADEMIC PRESENTATION

The educational merit of an academic presentation is strongly influenced by its context in a teaching program. While effective presentation allows ideas

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to take root, whether these ideas survive and grow depends on the educational environment engineered around the target audience. Thus, an approach to educational, academic presentation would be incomplete without addressing at least some aspects of constructing such an environment.

First, the educational environment must support, engage, and unite the diverse backgrounds and expectations typifying bioinformatics audiences by offering them shared challenges. This warrants a constructivist stance, whereby presenters encourage the assembly of new knowledge by engaging that which is pre-existing. Given the lecture-like context of academic presentations, it is advisable that the presenter heeds Mayer's [14] and Kirschner *et al.*'s [15] emphases on cognitive over behavioral student activity. In this light, the use of active strategies (see ref. [16] for review) encouraging deep cognition (see ref. [17] for discussion) is advocated to contrast the passive learning modes so easily triggered by the nature of slideware as a medium [5, 6, 18].

The target audience: the value of rapport

Bioinformatics education characteristically brings together audiences comprised of biologists and computer scientists. There is considerable inhomogeneity within each of these categories and presenters must understand and meaningfully engage their audience's collective knowledgebase. This engagement serves to connect presented content to the values and expectations of the audience and, thus, is likely to enhance its significance and retention [19]. The establishment of such rapport permits the presenter to guide and structure the audience's understanding as it develops. While qualitatively apparent, semiquantitative indications that audience engagement is a correlate of perceived lecture quality are emerging [20, 21], supporting presenter investment in audience awareness.

Biology is a culture shaped by technological breakthroughs [1] and modern biologists fluent in bioinformatics techniques are better equipped to impact their increasingly data-rich field [22]. The motivation of biologically minded students to learn bioinformatics is likely to arise from the same source that inspired them to learn basic optics for microscopy: a keen desire to observe the workings of the natural world. Thus, presenting bioinformatics in the spirit of computationally aided biological problem-solving may elicit increased attention and enthusiasm from this component of the audience. Similarly, presenting the challenges biological data

and systems pose to quantitative representation and computational processing alongside the ingenious methodologies developed in response, may engage those with computer science backgrounds.

Engagement of the kind described above may also have the desirable effect of promoting social aspects of learning and problem-solving in- and outside of the presentation environment. Students should be encouraged to face a common challenge in a collaborative fashion, bridging their domains and offering one another guidance within the framework of the course objectives. Most bioinformaticians have witnessed the mishandling of characteristically messy biological data by biologists who erroneously place mathematics outside of their core of expertise as well as the 'misapplication of quite brilliant quantitative minds to faulty formulations of biological problems' [1]. This testifies to the educator's responsibility to encourage collaborative inquiry between these groups to secure the future of data-rich life science. The live presentation is an ideal setting to initiate this process.

While a general understanding of the audience's make-up is helpful, pre-presentation surveys may grant more specific insights. Awareness of participants' educational background, learning styles and objectives, and (particularly important in international settings) cultural background comprises the first element needed to plan presentation content and delivery. Internet resources are available to assist presenters in quickly amassing and analysing this information and are suitable even for large class sizes (e.g. <http://www.surveymonkey.com/>). With such insights, educators may craft their presentation content and delivery to better suit their audiences and more effectively accomplish learning goals. Furthermore, the results of such surveys are easily shared with tutors and other supporting agents, for a comprehensive educational effort [23]. Readers are referred to Leung's article [24] for an accessible introduction to survey design.

Content: addressing coverage, depth and interdisciplinarity

Content suitable for live presentation is necessarily simple yet meaningful. When the breadth of expertise compiled in a discipline such as bioinformatics is paralleled with the constraints of any teaching program, realism in selecting learning goals and content is essential [1]. Achieving meaningful, functional simplicity is no trivial task when the subject itself inheres complexity; however, the benefits to communication, and hence education, are numerous.

Tibell and Rundgren's recent review of the educational challenges in the increasingly interdisciplinary and crossdisciplinary domain of molecular life science concludes that focus on key concepts and central principles supersedes the need for detail. This focus should be supported by training students to recognize patterns in the knowledge they construct [25]. Bioinformatics education faces similar content-level challenges and limiting information density in presentations promotes effective delivery by restricting cognitive strain [1, 11, 26, 27]. Details salient to establishing generic, 'runnable mental models' [25] have their place in live presentation; however, accessory details must be invoked with restraint to prevent interference during the acquisition of core models. The supplementary presentation accompanying this review aims to introduce BLAST to an audience of life scientists in this manner.

Simplifying key content and maximizing its pertinence to the audience are expected to increase the fidelity and durability of knowledge exchange. Indeed, in the current information age, it would be unfortunate if expert-audience interaction was dictated by low-level information transfer. Rather, academic presentations can contribute to Entwistle's model of teaching as an imaginative act, enlivening high-level information while equipping audiences with distinctive intra-domain ways of thinking and practicing (WTP) [17]. Such instructional strategy, he argues, is optimal in providing university students with the awareness required to confront content of 'super-complexity', where consensus is limited and factual knowledge in constant flux. In this line, presentation content illustrating the active process and experience of problem-solving and knowledge acquisition in bioinformatics, calling in detail when needed, and connected to the values of the audience's knowledgebase is well advised [28–30].

Delivering curriculum content of greater detail is best achieved through more task-oriented methods such as independent reading, practical work and projects [31]. The signature WTP delivered by effective presentation and coupled with clear task guidance is key in making this content accessible and meaningful. Widespread bioinformatics e-learning resources (e.g. <http://bibiserv.techfak.uni-bielefeld.de/bibi/Education>) may support this effort and have been well received by students [32, 33]. Additionally, switching between these modalities requires learners to construct internal meaning [10] and knowledge-acquisition techniques that will endure over

unstructured internalization. Provided that an adequate syllabus, specifying both the level of detail and the depth of understanding required [25], accompanies the process and that expert-audience interaction has demonstrated a degree of the inner logic of the subject and its pedagogy [17], learners are in a position to continually update their own knowledge and approach problem-solving maturely and creatively.

Lastly, the interdisciplinarity of bioinformatics involves content presentation from a range of experts native to disparate domains. This feature threatens content cohesiveness and may dampen the educational impact of academic presentations, regardless of their quality. It is important to avoid the 'fuzzy' treatment of terms such as interdisciplinarity. To this end, the elements of interdisciplinarity defined by Repko are called to mind, namely: '(i) addressing a complex problem or focus question that cannot be resolved by using a single disciplinary approach, (ii) drawing on insights generated by disciplines, interdisciplines, or schools of thought, including non-disciplinary knowledge formations, (iii) integrating insights and (iv) producing an interdisciplinary understanding of the problem or question' [34]. That interdisciplinarity education requires learners to take a very active cognitive role is clear and such a role should be encouraged even in the typically passive context of academic presentation. Ferguson's article describing the use of Bloom's revised taxonomy to 'team-teach' an integrated English–History course [31] may be instructive in this regard. By separating content into thematic units and establishing complementary goals for each learning event, teams of educators may more precisely formulate instructive strategy. Careful planning guided by learning taxonomies may thus limit content redundancy. Transposing Ferguson's reports to the present case, developing the factual knowledge of molecular biology alongside the procedural knowledge of computer science and mathematics will grant audiences perspective on 'why' and 'how' bioinformatics inquiry is conducted. Maintaining perspective and content cohesiveness translates to increased engagement and integrative learning across a presentation series. Furthermore, structured planning of interdisciplinary content clarifies learning objectives between educators which, in turn, enhances the design of consistent syllabi.

Content is the nucleus of communication, academic or otherwise. Once the parameters of

coverage, depth, and interdisciplinarity have been harmonized with a programme's learning objectives and the audience knowledgebase, the more immediate aspects of media-rich instruction may be addressed.

The medium of the presenter

As presenters, educators become the richest information source available to an audience. However, Blokzijl and Naeff [35] note that slideware often relegates speakers to the position of distracting 'stage-hands' in favour of a 'luminescent square of light' [5]. This is educationally detrimental: if presenters ignore (or evade) their ability to connect with an audience on a human level, they surrender control to their slideshow. In such cases, it must be asked whether student time is better spent on assigned readings or coursework. Understanding the influence of the presenter and exercising it with awareness is central in managing content delivery during an educational presentation.

Intelligent use of immediacy effects [36, 37] has been positively linked to student performance [38]. These effects are triggered by, for example, tone of voice, posture, dress, animation and facial expression. When immediacy effects correspond to the intellectual attitudes adopted by an expert in the treatment of domain content—the cautiousness of meta-analytical design, the healthy suspicion of statistical results, the excitement of validating *in silico* analyses in the wet-lab—they transfer a form of meta-content highly compatible with the medium of live presentation. To illustrate, consider facial expressions as a powerful mode of non-vocal communication. It has been noted that primate facial displays are highly intricate and are rendered by the most complex facial musculature of all mammals, affecting observable responses in human speech and eye gaze [39]. This meta-content is of considerable tacit value to students entering a field of abstraction. When presenters become versant in the use of immediacy effects, they acquire a key vocabulary in expert-audience interaction which may align student attention, thinking and learning to the intellectual character of course content.

Observer-expectancy effects are additional parameters academic presenters must be aware of. Collectively, these contribute to a form of psychological reactivity, altering audience behavior with respect to the cognitive bias of an observer. If presenters are bent on their audiences 'seeing the

point', they may unconsciously induce behaviors suggestive of success, but which are no more than superficial reactivity. The case of 'Clever Hans'—the arithmetically competent horse—is instructive. Apparent feats of intellect were shown to be a set of simple responses unconsciously cued by observers [40]. Analogous reactivity in human audiences is a great obstacle during assessment of student understanding. The presenter must ensure that expectations of the audience are well-informed and used to guide live interaction. This is not to suggest that educators should lower expectations of student performance. Indeed, higher expectations may translate to higher achievement (the Pygmalion effect [41]). Rather, the suggestion is that presenters who consciously construct their expectations based on their own performance and achievement of learning goals are more likely to elicit positive learner behaviors and accurate feedback. Additionally, presenters must ensure to 'normalize' their expectation of achievement from each component of a bioinformatics audience. This may be done on the content-level by presenting topics with similar degrees of conceptual challenge to each interest group (i.e. computer scientists or biologists). Aside from promoting an environment of collaboration, this measure avoids the formation and/or sustenance of achievement gaps induced by educator and student expectancy [42, 43].

Many bioinformaticians are more focused on active research than teaching. Counsell's [1] review of bioinformatics education in the UK notes the regrettable phenomenon of the disinterested bioinformatics educator faced with the weighty duty of teaching that brings little professional reward in comparison to successful research. The question, then, is how to apply a researcher's mindset to bring about successful learning in the lecture hall. Inquiry-based learning strategies [44, 45] may offer a solution. In this model, researchers treat teaching as a form of guided inquiry where students design, conduct, and evaluate experiments based on the materials available to them. In a presentation setting, these experiments are conceptual in nature and content disclosed by the presenter is coupled with the audience knowledgebase to define the available materials. The presenter then introduces the method of inquiry and provides guidance in its execution before eliciting participation in aspects of the process. The example of transposon mutagenesis in the supplement offers such an opportunity. The author worked on a

similar system during his bachelor studies—a fact which may be revealed to build rapport with the audience. Efforts to align lectureship and presentation with research methodology may thus benefit the presentation of WTP between researcher–educators and their audiences.

The points above aim to stimulate reflection on the role and medium of the academic presenter. In summary, presenters who carefully consider their impact as an information source are in better control of the educational experience.

VISUAL COMMUNICATION: A FORCE TO BE RECKONED WITH

The visibility of multimedia presentations is not to be taken lightly. A guinea pig's retina of 10^5 ganglion cells is thought to transmit information to the brain at $875\,000\text{ bits s}^{-1}$ suggesting that each human retina ($\sim 10^6$ ganglia) can achieve transfer rates around that of a 10 Mbit Ethernet connection [46]. In humans, natural selection has tied visual information processing into a range of behavioral and cognitive functions [47–51] and may have triggered the development of the frontal cortex and skilled activity [52]. Visual input has immense potential to structure cognitive activity and, therefore, must be handled with care in an educational environment.

Focused visuals that clearly support content may control audience attention and elicit behaviors beneficial to learning in a social context [53]. However, the mere presence of poorly composed visuals or superfluous effects (misapplied motion, color, emphases, etc.) can generate cognitive load and reduce the neural 'processing power' available to understand any content presented. Slideware has greatly facilitated the production of visuals, but cannot automatically bestow communicative worth on its products. Duarte's maxim that 'to succeed as a presenter, you must think like a designer' [13] is fitting in this regard. Educators who literately use visual aids employ basic principles of design in a deliberate effort to support their teaching.

A thorough discussion on visual communication is beyond the scope of this review; however, there are ample introductory texts on the subject. Moore and Dwyer's *Visual Literacy* [54] consolidates numerous perspectives while Lester's *Visual Communication* [55] provides a comprehensive overview of the field. Tufte has authored several books on effective data visualization including *The Visual Display of*

Quantitative Information [56], *Envisioning Information* [57] and *Visual Explanations* [58], which he has described as 'pictures of numbers, pictures of nouns and pictures of verbs', respectively. Finally, Beakes [59] offers a personal reflection on the power and usage of images in teaching biology.

Practical and approachable guides by professional designers and presenters are also available. Amongst others, Reynolds' *Presentation Zen* [11] (also see <http://www.presentationzen.com/>) and Duarte's [13] *Slide:ology* can afford academic readers useful viewpoints on the medium's nature as well as advice on elements of slide composition such as space, contrast, repetition, hierarchy, 'eye flow' and pace. Wariness must be exercised when translating some of these strategies to the lecture theatre, however. Academic meaning, particularly in the microscopic and abstract domains, is often subtle and not amenable to representation with rich visuals. Images that stray from the iconographic tend to connote a highly individualized web of meaning which, if not managed skilfully by the presenter, can quickly interfere with the audience's construction of accurate knowledge. In such fields, metaphor and analogy referring to 'everyday' reality are valuable, but easily hyper-extended [25] regardless of whether they are verbally or visually transmitted. Academic presenters should, therefore, carefully choose their visual techniques, ensuring they reinforce content rather than distract from it.

With the presenter's visual literacy developed enough to see use of bullet-points and undirected special effects as an exception rather than a rule, slideware may become a trusted tool rather than a potentially subversive element.

MODES OF DELIVERY

Since 1984, the non-profit 'Technology, Entertainment, Design' foundation (TED; <http://www.ted.com>) has conducted conferences dedicated to 'spreading good ideas'. The presentations available on TED's website are not formatted as academic lectures, but comprise a valuable repository of presentation styles. Several elements of delivery employed by TED speakers as well as their educational value are described below.

Rosling's presentations [60] first engage the commonly held preconceptions of the 'developing world' before skilfully deconstructing them with clear verbal and visual argument supported by an

assortment of datasets. His style, involving a combination of slideware and specialized software, prompts cognitive participation from the audience. Well-animated visuals support the reconstruction of knowledge in line with Rosling's arguments. In a bioinformatics lecture hall, a well-scripted switch to a terminal window, web browser, or other appropriate tool to enliven content may similarly enhance learner participation.

Eglash [61] builds a credible line of argumentation which connects deterministic chaos, Gottfried Leibniz, and binary code to western geomancy, Bamana sand divination, and projects promoting mathematics achievement in African-American schoolchildren. Presenting content alongside the story and significance of his research weaves this assortment of phenomena into a memorable instructional event. Researchers who develop approaches to guide students through the comparably eclectic blend of knowledge and technique in bioinformatics inquiries may stimulate similar 'meaning-making'. Such meaning can motivate even extra-domain learners to immerse themselves in the culture of bioinformatics and conduct worthwhile inquiry [62].

Visualizing biological or computational phenomena, especially at an abstract level, is not an easy task. Symbolic representations which bring intangible quantities into a common frame of reference are useful here and used by Bassler to describe information content and flow between bacteria and higher organisms [63]. Striking yet simple visuals depicting the comparative size of the human and its microbiome in terms of cell numbers and genomic content provide even the uninitiated with a lasting sense of perspective.

Lessig employs a presentation style where the rapid display of short phrases or pictures accompanies and augments his narrative [64]. Known as the 'Lessig Method', this represents a less extreme version of the text-only 'Takahashi Method'—employed by a programmer conscious of his lack of experience in using slideware for visual communication. A compelling pedagogical strategy is activated when text in a slideshow is designed to be decoded visually and in the context of a speaker's content rather than by 'standard' reading. To exemplify, readers are referred to the communicative synergy of simplicity, color, size, motion and sound in the Adobe Flash® presentation introducing a social project known as the 'Girl Effect' (<http://www.girleffect.org/video>). With these cases in mind,

educators are encouraged to imagine the potential of visuals in presenting command-line tools such as 'grep', 'sed' or the principles of regular expression that underlie much of their function. Even the workings of more complex tools such as BLAST [65] can be illustrated using text or text-like elements as visual actors. These presentation modes may better promote visual thinking, conceptualization, and learning where language often falls short. This is particularly helpful in international settings where linguistic conventions in documentation may be of limited use. Slideware users may easily generate such graphic sequences and can visually represent the meaning of their content with considerable educational effect.

Most of these presentations make use of relevant analogies or metaphors, a strategy recommended by Tibell and Rundgren when used with caution [25]. These authors point out that domain-specific language and visualization in an inter-domain setting is a considerable obstacle. Visual metaphor offers an alternate rendition of meaning and can lessen the impact of domain-restricted representation. To illustrate, the politician Omar Ahmad [66] presents strategies to influence elected officials and uses fitting visual metaphors from animal ethology as accompaniment.

Elements from the above modes of delivery have been integrated into the supplementary presentation accompanying this review. Comments on their intended effect and rationale may be found in the notes section below each slide.

CONSCIOUSNESS ENGINEERING IN THE CLASSROOM

The academic presenter calls audience- and self-awareness, apt content selection, and literate visual communication into play to shape the collective consciousness of the classroom. This section proposes a framework, adapted from Gagné's conditions for learning and instruction [67] and previously applied to PowerPoint by Antonacci [68], for the delivery of an academic presentation. Gagné's focus on cognitive psychology and information-processing theory is well-suited to guide the selection, arrangement and presentation of content for instructional purposes. Each brief subsection below corresponds to a component of an educational presentation and features viewpoints from selected literature.

Pitching content and presenting learning objectives

The beginning of the academic presentation should aim to pique audience curiosity by engaging existing knowledgebases while identifying the learning objectives of the talk. Posing an audience-aware opening question supported by strong visuals is one approach to these ends. When beginning a presentation on BLAST, for example, a series of slides analogizing the algorithm's key features in popular phenomena will help motivate and unify audience participation (see Supplementary Data). In Gagné's model, this stimulus activates and orients the learner's physiological channels of reception. For an audience of learners, it provides a rallying point for attention and common ground for subsequent interaction.

Clear learning goals and expectations are particularly important in reducing student anxiety connected to assessment. Reduced anxiety is likely to aid memory formation and recall [69–71] and possibly prevents the impairment of cognitive function [19]. The educational presentation will only succeed if audience stress levels are monitored and managed by presenters. Preparing for ill-characterized summative assessments is perhaps a primary source of academic anxiety and motivates students to learn in a shallow, fact-hungry manner [21]. It is reasonable to expect that aligned learning objectives, course content and assessment will ease this anxiety and promote deeper learning in the classroom. Direct techniques to enhance learning by managing stress through cognitive analysis, affect modulation, and motivational imagery have been reviewed elsewhere [72] and, given their correspondence to the active learning and visual communication techniques discussed above, their application during presentation is not unfeasible.

When 'pitching' topics, it is important to remember that all attention-gaining strategies must be 'honest' insofar as they accurately represent scientific phenomena. When content is presented in an overly exaggerated or distorted fashion, a degree of learner trust is likely to be lost and educational merit suffers.

Engaging the audience knowledgebase by stimulating recall

Here the presenter acts on more detailed knowledge of the target audience gleaned from surveys or revisits previously accomplished learning goals. Meltzoff *et al.* [53] assert that learning is a statistical phenomenon and patterns in the invocation and use

of knowledge enforce the establishment and recognition of significant meaning. Similarly, Gagné posits that long-term encoding is improved by linking new information to pre-existing schemas in the learner's knowledgebase. These schemas may derive from both previous learning within a given course and learners' individual history. It is then no surprise that professional designers, presenters and storytellers also attempt to appeal to their audience's experiential background before introducing new stimuli to heighten significance and impact [11, 13]. The supplementary presentation—an isolated case of instruction—attempts to stimulate recall by repeating slides at opportune moments (e.g. after step '8v1') to build on previous cognitive activity.

Present content as stimuli

As discussed above, carefully designed visuals and a deliberate approach to stimulate content-specific cognitive activity are central to the promotion of learning. Paralleling Gagné's reasoning, presenters who provide content as a stimulus directed at an appropriately oriented audience knowledgebase are likely to trigger an accurate construction of meaning. Discussion of the biological facets of bioinformatics presentations may be, as Beakes suggests [59], enhanced by rich accompanying visuals. Rich visuals paired with 'unruly' biological systems contrasted by iconographic and 'controlled' slides accompanying more regimented concepts serve to mirror suitable WTP. Further stimuli are offered by immediacy effects rendered by the presenter. These should also reflect appropriate attitudes and WTP with respect to the content presented.

Guiding inquiry by the worked-example effect

The bioinformatics presenter serves as an object of study and emulation in the construction of procedural knowledge and its context. This 'worked-example effect' is reported to increase cognitive activity while imposing low levels of cognitive load [73–76]. To close the supplementary BLAST presentation, for example, the presenter guides the audience through an instance of the algorithm's application in molecular genetics. Switching to a web browser for a 'live' solution offers an opportunity to exercise the medium of the presenter (see above) and further establish rapport with the audience.

Eliciting performance, feedback and assessment

The strategy of breaking a lecture's narrative every 15 min in favour of short sessions of learner activity (ca. 5 min) has been received well by students [77]. This technique keeps the length of content delivery within the potential window of sustained attention. These 5 min windows may be dedicated to short puzzle-based learning activities [78], such as selecting the right databases to address a particular biological question. Several slides in the supplement offer opportunities to begin such activities. Use of a white-board (or similar) to consolidate key points during these activities is common practice among educators.

Concise checks for understanding via multiple-choice or short-answer questions may also be performed. After a short (2–3 min) period of learner reflection (introspective knowledge-building) or group work (social knowledge-building, ideally between learners with different backgrounds), learners may report their conclusions to the presenter. Vocal responses, a show-of-hands, or other such means may be used. Technologies such as audience response systems [18, 79, 80], which gather anonymous (and arguably less inhibited) audience responses through, for example, handheld 'clickers' and display results in the presentation are growing in popularity. Internet resources which use mobile telephony or social networking services to similar effect are also available (e.g. <http://www.polleverywhere.com/>) and are feasible methods to gather representative feedback. With larger audiences, managing active sessions while clearly communicating expectancy may involve specialized strategies which are discussed by Walker [81].

Slideware and presentation technique can focus attention while audiences are encouraged to actively apply and associate new content to an appropriate task. Such breaks from sustained attention that maintain a positive learning environment are useful in accomplishing educational goals. Furthermore, the results of such exercises act as formative feedback to presenters, helping them dynamically adapt teaching to a plastic learning environment [80].

Promoting sustained learning

Once new content has been presented, its nature demonstrated, and its application realized, Gagné asserts that generalizing new knowledge will promote retention. In this context, the presenter is advised to conclude with a broader, 'big-picture' viewpoint

that aligns in-class outcomes with the initial learning goals and their 'real-world' consequences [30]. Active learning and formative assessment mechanisms provide presenters the material required to conclude in such a tailored manner.

Presenters may provide supplementary information with links to literature and resources that address the course's learning goals. Ideally, these should be accompanied by recommendations on their use. Approachable primers on a variety of subjects including hidden Markov models [82], network interpretation [83], read mapping [84], genome browsing [85] and the origin of matrices such as BLOSUM62 [86] are suitable for this purpose. The latter primer is ideal to unite the concepts of computational sequence analysis with the effects of natural selection on the genome and can easily follow up the supplement. Creating mixed student groups to discuss the material out of class is an attractive strategy to promote social learning. Alternate sources of learning material such as MIT's Open CourseWare (<http://ocw.mit.edu/OcwWeb/>) may also be of value to students.

Assignments and practical courses extending the understanding constructed in presentations may help 'fix' learning [23]. Computer-assisted instruction, when rendered as an active strategy, has been credited with enhanced learning outcomes in bioinformatics [87]. In essence, the learning effects of presentation should blend seamlessly with the larger environment of teaching and learning in bioinformatics.

CONCLUDING REMARKS

Teaching and learning in the 21st century has become a communication- and media-rich undertaking, challenging pedagogy to integrate new forms of information literacy into its evolution. Visually engaging presentations and increasingly learner-centric teaching are at the forefront of modern lectureship and bioinformatics education may benefit greatly from innovations in these fields.

Familiarity with current pedagogical thinking and communication strategies may allow bioinformatics educators to integrate presentation software and lectureship in aid of fluent, enlivened and deeply educational academic communication.

SUPPLEMENTARY DATA

Supplementary data are available online at <http://bib.oxfordjournals.org/>.

Key Points

- Effective academic presentation requires visual literacy, audience-awareness and clear learning objectives.
- Academic presentations benefit from audience-oriented content to stimulate cognitive activity and learner engagement.
- Academic presentations serve to enliven high-level domain content and infuse audiences with its meaning.
- Bioinformatics presentations should aim to inspire quantitative scientists to apply their expertise to the biological domain while motivating life scientists to engage new frontiers and tools in biological enquiry.
- The success of educational presentations depends upon the other aspects of a taught program to reinforce and extend content and meaning.

Acknowledgements

Foremost, the author sincerely thanks his teachers, colleagues and students for their helpful perspectives and support. Thanks are due to Miriam Grace for her insightful comments and Prof Dr Frank Oliver Glöckner for his review of the manuscript.

FUNDING

Max Planck Society.

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