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Instructional Design: Development of a Clinical Photography Course for Undergraduate Dental Students at the University of Leeds

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Introduction

Clinical and dental photography is an acquired skill. It is learned, developed and practised at post-graduate level by medical photographers across the U.K. But where does the medical photography profession stand in terms of transmitting slowly acquired skills to a wider clinical audience? If some or all skills need to be passed on, how and to whom should they be taught?

This paper considers how dental practitioners may benefit from training in specific aspects of clinical photography and suggests a model of instructional design for a clinical photography course proposed for undergraduate dental students studying at the University of Leeds.

Training Requirements

Easy and routine access to photographic support services is available to dentists in most large hospitals but absent, or difficult to access, by those working in small or medium-sized practices. Of course, dentists can and do use photographic equipment as and when required but, in contrast with X-ray imaging, they currently receive scant training in technical, legal and ethical aspects and matters arising from the production, use and retention of surface images. At best such training is episodic, offered as and when opportunity allows.

Weaknesses in training are likely to become more problematic with the increasing use of photography in dental practice consequent upon the seemingly inexorable rise in medico-legal claims (Theddu.com 2017); the use of images in marketing cosmetic services; and opportunities to manipulate images for diagnostic, communication and commercial purposes presented by recent advances in digital photography. Use of clinical photography by dental practitioners increased from 36% in 2004 to 48% in 2010 (Morse, Haque, Sharland & Burke 2010), a rate of increase which, if sustained, raises the question as to whether it is adequately addressed in current dental training programmes.

Current and Future Training Provision

Courses in clinical photography have traditionally been offered as optional extras or updates for qualified professionals (Royal College of Surgeons, 2017) rather than as core components of undergraduate training. Such courses complement and target the same audience as that for published articles and online guidance (Nayler, 2003). Although of undoubted value, the effectiveness of these and other mechanisms for peer-to-peer sharing and updating may be limited when – as with clinical photography – their contents cannot build on foundations of knowledge, ethics and practice established during

undergraduate training. In the absence of such foundations, clinical photography may, at best, be perceived as an exotic pastime of interest to a minority of enthusiasts and, at worst, as a set of mechanical skills lacking broader intellectual and professional significance (Newbury, 1997).

It must, however, be conceded that the inclusion of dental photography as a mandatory and assessed component within overcrowded dental undergraduate courses could be a step too fast and too far. Before contemplating such a step we must be confident, first, that the salience and significance of photographic imaging in dental practice is sufficient to justify inclusion within undergraduate training; second, that such inclusion is likely to have a positive impact upon routine dental practice; and third that it is possible to design and deliver cost-effective undergraduate units in photographic imaging. In the latter connection, it must be admitted that although existing courses for qualified dentists are successfully staffed by clinical and photographic professionals with scant input from clinical educators this model is unlikely to transfer successfully to undergraduate training. In the best of all possible worlds, an undergraduate clinical photography educator would combine field expertise in clinical photography with competence in medical education. In the real world such omni-competent hybrids are few and far between and, as at Leeds University, we must strive to forge effective (and cost-effective) partnerships between clinical photographers and clinical educators. Joint authorship of this article is a preliminary test of one such partnership. Is it possible for a clinical photographer and a clinical educator to agree the objectives, content and design of an undergraduate unit that looks and behaves more like a serviceable donkey than an ungainly camel?

Learning Objectives & Instructional Design: Looking to the Past

We use past learning - what we know or think we know - to make sense of new learning. When gaps between existing and new propositions, concepts and procedures are small, learning is usually trouble-free. When gaps are wide students either:

(a) Reject what they are taught as confusing or nonsensical
(b) Memorise facts and procedures they can neither explain nor justify
(c) Select and distort new material to render it consistent with previously-learned facts and ideas

It follows that, when drafting objectives for new learning we must be mindful of what students already know, and hence of how they are likely to have made sense of what they've been taught. Even when they continue to work hard, students in difficulty may cease to expect learning to necessarily 'make sense' and become as willing to suggest answers to logically insoluble as to soluble problems (Schubauer-Leoni & Ntamakiliro, 1998).

Beginning with Piaget and Vygotsky in the early twentieth-century, constructivist psychologists of learning have investigated the ways in which students make personal sense of what they are taught, how this 'sense' tends to develop in response to experience and education, and the implications thereof for instructional designs and processes (von Glaserfeld, 1995). When training dentists in clinical photography it is obviously necessary to identify starting and finishing lines for technical knowledge and skills. In addition, we must also need to ensure that dentists understand how to make

sense of, and hence apply, their new learning in overlapping medical, professional and legal contexts. For example, dentists should be able to identify and manage issues of consent with respect to dental photography. Such issues extend beyond the legal (as to when consent may be said to be fully informed) into those of professional norms and standards (as to whether such consent is in a patient's best interests). Unless trained so to do, 5th year undergraduate dental students may not even consider issues of consent with respect to non-medical interventions and procedures let alone do so to the standard required. This is because we organise the basic elements of knowledge and skill into what constructivist learning theorists call 'schemas' – discrete but interconnected systems of fact and process which, when activated by internal or external stimuli, enable us to think and act. Some schemas become automated and enable us to drive cars, and perhaps even drill teeth, whilst thinking about other things. In contrast, the more complex schemas allow us to take common-sense for very long walks, rationalise and reorganise the contents of simpler ones and, every so often, have 'light-bulb' moments.

To varying degrees every schema connects with others, both in lateral networks and in hierarchical supra-schemas wherein lower-level schemas serve as elements within higher-level ones. It follows that, in addition to extending, complicating and refining whatever photography schemas dental students already possess, we should ensure that appropriate lateral and hierarchical connections are made with relevant medical and professional schemas. Taken at face value, the downside of so doing includes extending the range of prior learning that must be taken into account, increasing the number of ILOs (intended learning objectives) specified and complicating our instructional design. However, consideration of students' prior learning from previously taught units of the Leeds University undergraduate course enables identification of starting points for a medical photography unit. By the fifth year, an understanding of consent requirements, legal issues and professional standards should be firmly imbedded in students' minds. What is new and unfamiliar is the linking of such knowledge, embedded in hierarchically-ordered networks of dense and complex schemas to what are certain to be simple and less integrated schemas pertaining to leisure usage of digital cameras. The implications of this are counter-intuitive: training will be more effective if we start by building upon what students already know about dental practice (extending the medical, professional and legal knowledge students already possess to encompass the new context of medical photography) rather than by enhancing their photographic skills and then attempting to connect new knowledge thereof to pre-existing knowledge of dental practice (Paas, Renkl & Sweller, 2003). Knowledge that can be used to solve new problems (e.g. re medical photography) in familiar contexts (established by 4+ years of dental training) is better understood and more readily activated than knowledge that can only be used to solve problems specific to the context in which it was taught (Day & Goldstone, 2012).

Building new knowledge upon foundations of existing knowledge can be problematic. Students completing the same course rarely, if ever, possess equivalent, let alone identical, knowledge, understanding and competence. In practice we must seek to build upon learning outcomes common to most, if not all, students (Terhart, 2003) and strive to remediate individual errors and misconceptions during individualised feedback, tutorials and training sessions designed to expose and correct gaps and misapprehensions in knowledge and reasoning. Since such opportunities for review, correction and reinforcement are necessary to address gaps and misconceptions in new learning problems, those consequent upon fractures and distortions in foundation learning may be deemed natural features of the training territory. This notwithstanding, it is advisable to

specify the first objective (ILO) in ways that yield information about prior learning for use by course tutors as well as to specify targets for new learning by students. For example, an initial ILO might state that, by the end of the first training session, students would be able to identify the range of purposes for which medical photography might be used in dental practice. While the final phase of such a training-session should be reserved for tutor exposition and mapping of such purposes, its main body could be devoted to a Socratic dialogue between tutor and students. Students could be told that, on the basis of prior training, they already knew all that was needful to be known and simply had to interrogate and apply such knowledge. The tutor might then probe and 'stress-test' their suggestions and arguments. In this way students would strive to make possible connections between their expert knowledge of dentistry and everyday understanding of photography while the tutor was appraising their knowledge foundations, noting gaps and misconceptions for future reference.

Learning Objectives and Instructional Design: Creating the Future

Course design is effective when instructors look both forwards and backwards: forwards towards competences demonstrable with required degrees of autonomy across a range of professional contexts, and backwards towards known or estimated starting points. Start-points are specifications of essential knowledge, skills and conceptual understanding attributable to most, and ideally all, students accepted onto a training course. Inferred from student qualifications, entry tests and interviews, start-point foundations should be conservative and invoked during initial training sessions. End-points, i.e. course aims, are statements of minimum competences that the majority (perhaps 85%) of students are expected to have achieved on course completion e.g.:

Course Aim

To enable students to undertake dental photography of a sufficient quality to be used within a future dental practice whilst adhering to professional and ethical standards.

 (For award-bearing courses fulfilment of such aims by graduating students is guaranteed within rarely disclosed margins of error.) Course aims may also list competences over-and-above the guaranteed minimum that significant numbers of students are expected to acquire.

For multi-session course units, it is also necessary to identify and isolate the learning steps through which students move from what they already know, understand and can do towards the end-point competences specified (Barman, Silen & Bolander-Laksov, 2014). Of course, such 'steps' also exist within most training sessions, but their role in course planning differs. Within a session, an instructor can do no more than play it by ear, adjusting inputs, timings and expectations as students' questions, answers and task responses dictate. Between sessions an instructor can analyse and reflect on evidence of students' skills, knowledge and understanding obtained during and/or subsequent to the session itself, and modify the substance, sequence and/or ambition of learning 'steps'

initially planned to lead from fixed start- to necessarily variable learning end-points. Tutors may find that while start- and end-point specifications for course entry and outcomes remain constant over time, step-points (session objectives) require minor or significant revision from year to year.

Specification of start- and end-points for a course in clinical photography may appear deceptively simple: establish the photographic skills students can be assumed to possess and define the photographic competences of potential relevance to clinical contexts. The tacit assumption underlying such specifications is that dentists fail to make full and appropriate use of photographic imagery because their technical knowledge and skills are limited. In reality, however, such failures may follow from disconnections between their professional, legal and clinical knowledge on the one hand and whatever they happen to know about photography on the other. Whether or not this is so, there are good reasons to build the proposed course on expert clinical rather than lay photographic foundations. Constructivist research indicates the difficulties we have in forging productive links between hitherto disconnected schemas – in particular between schemas located in 'expert' and 'commonsense' domains (von Glasersfeld, (1995). Dentists are certain to have encountered still and moving photographic images in training and professional updating, but most are likely to have focussed on the 'what' rather than the 'how' or 'wow' of the images. It follows that proposed courses should build upon generally known and accepted foundations of clinical knowledge, professional and legal obligations and establish the range of potential purposes capable of being served by dental photography prior to developing the practical competences necessary to fulfilling such purposes. In sum, competence in the 'how' of dental photography should be grounded in understanding of 'what', 'when' and 'why' x, y and z could or should be done. Only when these learning-steps, i.e. objectives, are satisfied can technical 'how' objectives begin to signify. Course design conforming to these principles should ensure that competence develops from the interconnection and fusion of knowledge and skills drawn from otherwise discrete and disconnected schemas (Van Merrienboer & Sweller, 2005).

Effective course design also demands that specification of learning-steps, i.e. session objectives, between start- and end-points complies with SMART criteria (Tofade, Khandoobhai & Leadon, 2012):

Specific: Objectives must clearly state what it is intended that students will learn, i.e. what they will know and/or understand and/or be able to do by the end of a single or series of training sessions that they did not previously know and/or did not understand and/or could not do. In principle, intended learning gains should apply to all students. In practice, learning gains must hold for the majority of students. (N.B. when course designers/tutors are unable to control recruitment, prior attainment in a student population may be so varied as to render this requirement unobtainable.)

Measurable: This criterion is a test of the clarity and precision with which session-specific learning objectives are formulated. Objectives are deemed to be 'measurable' when intended learning (or the lack thereof) can be recognised, when it is clear what counts as evidence that appropriate and adequate learning is taking **and** has taken place. For certification and reporting purposes it is necessary that, within acceptable margins of error, summative end-of-unit (or end-of-training) assessments yield evidence as to whether or not learning objectives have been met by each and every student. It is also

important that, during and at the end of training sessions, tutors are able to obtain evidence of *students' learning by monitoring their* answers to questions and responses to tasks in order to inform and adjust delivery of the current and plans for subsequent sessions. Although *sometimes confused with 'formative' assessment, in*-session monitoring dodders from it in three respects: (a) it *seeks evidence of 'learning in progress'* not *'end*-of-*course outcomes'; (b)* the reliability and validity of monitoring evidence and judgements cannot be established; and (c) judgements can rarely, if ever, be made about the learning of all students. This notwithstanding, it is essential that session as well as end-of-unit objectives be assessable in principle. It must be theoretically possible – if not immediately practicable – to determine whether or not the learning intended is taking or has taken place. In sum, learning statements that defy binary (yes/no measurement) lack real-world meaning. They are comparable to indeterminable pathologies in medicine.

Attainable: Session objectives must be achievable given the prior learning and abilities of the student population, the estimated effectiveness of training strategies and techniques to be deployed, and the time and resources available. Commonsense dictates that less be attempted in 45 minute than in 2 hour sessions, with groups of 60 than 15 students, and with slower or less-committed than with quick-witted and keen students. Less obvious, however, is the importance of minimising the number of discrete (or seemingly discrete) objectives specified for a given session, and of estimating the difficulty of learning steps between contiguous points in a sequence of session objectives. Rules of thumb for maximising the attainability of objectives include:
    (1) Unless objectives can be easily and quickly fulfilled (or are scaled to allow for *differences in students' prior attainments)*, the number specified for each training session should be kept to a minimum.
    (2) Obstacles to learning and potential misconceptions should be anticipated. In particular, course designers should bear in mind that students often simplify what they are taught (i.e. learn by rote rather than striving to understand) and make false sense of new material by assimilating it to what they already think they know.
    (3) Although learning can be a single-stage or one-dimensional process, it is usually more complex. While some objectives may be fulfilled within the compass of a single training session, mastery of more complex objectives might require two, three or more sessions plus inter-session tasks. What is taught in one session might need to be reinforced in a second (in order to eliminate errors and misconceptions in learning) and consolidated in a third (to connect new learning with existing knowledge and action schemas).
    (4) Avoidance of setting unrealistic session objectives in a vain attempt to meet unrealistic end-of-course aims. All too often the time and resources allocated to individual *courses, units and modules fail to allow for students' prior learning, their start*-points. Rather than demanding that students take unrealistically large learning-steps within an insufficient number of training sessions, course designers and tutors should strive to take students as close to, albeit short of, the desired end-state as possible. Conversely, if time and resources permit, students should be taken as far beyond officially prescribed learning destinations as they are able to go.

Relevant: This criterion amounts to a plea for parsimony as well as completeness in the specification of course objectives. It is obvious that no gaps in a series of stepping-stone objectives leading from prior learning start-points to course end-points should exist, but *the relevance criterion also proscribes the inclusion of 'nice*-to-*have' alongside 'must have' stepping*-stones. In cases where it is possible for course aims to be exceeded by

the majority of students, however, this criterion may be relaxed. A course may legitimately seek to broaden student learning above, beneath and beyond target end-points and/or to enrich learning experiences en route, provided that so doing neither degrades nor diminishes end-point learning prescribed for students. In sum, the relevance of every learning objective and experience should be evaluated but not necessarily censured.

Time bound: In the best of all possible worlds, time allocations would be dictated by student learning speeds and course ambitions. In the real world it is necessary to estimate the size and speed of student learning steps, the range of student needs and differences and, in consequence, what is achievable in each fixed-length training session. *Such estimates are likely to require updating whenever disjunctions between what 'is' and what 'ought to be' become all too apparent. On such occasions solutions may need to be* creative. Instructional clockwork is imprecise and rarely synchronised with real time learning. Trainers need art and magic as well as wristwatches and bureaucracy.

A second 's' may be added to the SMART acronym: 's' for 'shared'. Objectives should be translated into 'student-speak' should be shared with students at the start of each session (or group of sessions covered by a single or set of objectives) and reviewed at its end. For example, in a session introduction students may be asked to answer a question or solve a problem. The objective, in the guise of question or problem, may then be revisited during the end-of-session plenary and students asked to compare and contrast their answers/solutions with those initially given. Students may then be required to describe how their answers had changed or why they had initially failed to solve the problem presented. Students' perceptions of their own learning can serve as evidence of what has and has not been learned. Evidence of mis-learning may also be exposed.

Using the SMART(S) Procedure in Practice: An Illustration

Fourth and fifth year undergraduate students may be assumed to possess sound understanding of legal and ethical issues pertaining to issues of consent, confidentiality and best interest with respect to dental investigation and treatment, cosmetics and prostheses but not necessarily to the production, use and retention of photographic imagery. An initial ILO conforming with SMART(S) criteria and designed to connect with prior knowledge might be framed as follows:

By the end of the initial teaching session the learner will be able to provide valid solutions and rationales to ethical and legal problems and dilemmas presented through hypothetical case studies in the context of clinical photography.

The example above is **specific** as it makes explicit actions required to meet the ILO (i.e. solve and provide rationales) in defined contexts (hypothetical ethical/legal clinical photography scenarios). The intended learning is **measurable** in that (a) courses of action recommended by students will either conform with or contravene legal requirements and/or professional standards; and (b) for recommendations deemed both legal and professional, analysis of the justifications advanced will enable judgements to be made as to whether acceptable actions have been recommended for acceptable reasons, i.e. whether or not students can be trusted to make the 'right call' all of the time rather than 'some of the time'. The specimen ILO is arguably **attainable** in seeking to extend proven competence in

meeting professional and legal requirements to a new technical context, that of taking, using and storing photographic images. In reality, however, judgements against this criterion can only be made once the capabilities of particular groups of students, teaching time and methods are known. Failure to meet this criterion through excess caution or lack of ambition is also possible: hurdles must be neither too high nor too low for students of given leg length. The ILO may be considered **relevant** to emergent dental practice to the extent that projected increases and developments in the use of photographic imagery, e.g. to illustrate anticipated outcomes of cosmetic interventions, are fulfilled**.** It is **time bound** in specifying what students should have learned and be able to do by the end of the initial training session. The ILO is also easily **shared** with students by, at the start of the training session, asking them to apply their prior knowledge of legal frameworks and professional standards to photography related issues and dilemmas which they are unlikely to have encountered in the first four years of training.

Conclusion

Ownership of technical clinical photography skill rooted in understanding of professional standards and ethical/legal requirements is fast becoming an expectation of dental practitioners. For this reason, clinical photography teaching for undergraduate dental student seems to be a sensible "next step" to ensure that the dental graduates leaving the University of Leeds are "fit for purpose". However, an impasse may quickly be met when field expertise is present without teaching expertise. Learning is complex and is most successful when novel information/skills are linked to what is already known. To design learning episodes that link new to prior knowledge demands skills and theoretical understanding of cognitive architecture beyond the purview of most clinical field experts. In consequence, transfer of expert knowledge to undergraduates might benefit from active collaboration between field experts and clinical educators.

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