The Future of Instructional Designing in Medical Education: Letting the Computer do the Work

Dr. Pandula Siribaddana MBBS, Postgrad.Cert.Med.Edu.
Lecturer in Medical Education, Postgraduate Institute of Medicine, University of Colombo.
E-mail for correspondence: pasiribaddana@yahoo.com

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Abstract

Instructional Designing (ID) is an important aspect of any curriculum development process and Medical Education is of no exception. Unless sound Instructional Design practices are met accordingly, it would be impossible to gain high quality learning or to achieve the intended objectives. Many of the Instructional Designers in Medical Education are Subject Matter Experts than Educational Experts. Therefore, Medical curricula in Sri Lanka as well as in the world are facing the lack of application of educational principles and theories to the Instructional Design process of such curricula.

In view of this deficiency, a process of automating the Instructional Designing has been tried in several instances with variable successes. Most of these systems are designed based on general Instructional Design theories and for non medical instructional processes. Therefore, the review analyses the existing instructional design theories and how the prototype automation systems have addressed the issues in facilitating the needs of Subject Matter Experts. By discussing these systems in a Medical Educational context, the review was able to make suggestions on how to incorporate automation technology to the Instructional Design process related to Medical Education and elaborate on the advantages that it would bring to the Subject Matter Experts as well as to the curriculum as a whole.

Keywords : Instructional Designing, Automation, Medical Education, ID, Subject Matter Experts, ADDIE Model, Harden, RLO, SPICES, Expert CML, ID expert.

Introduction

Effective and efficient Instructional Designing (ID) would be an important key to a successful curriculum or a programme of study. Whether it is in medicine or any other field of study, the basic approach in ID is rather similar. Although achieving a 'perfect set of instructions' would most likely be an intricate task, this would be deemed impossible if the designer lacks the expertise in ID. Institutions worldwide are seeking solutions to bridge this gap in ID.

'Medical Education' is a relatively new field of study for the Sri Lankan educationists. More and more Universities have established their own Medical Education Units for curricular support. Setting up these Educational Units, though they address the basic need of keeping the study programmes on track, is not the solution to the increasing demand for new programmes, especially in a field like medicine. This has created a vacuum, which echoes the need for more educational expertise to be disseminated aiming at the trainer community (e.g. Clinicians) who are the Subject Matter Experts (SMEs).

Postgraduate Training in Sri Lanka: The Need for Technological Integration

The Postgraduate Institute of Medicine (PGIM) of the University of Colombo conducts around 50 study programmes ranging from Certificate Courses to Doctorates in Medicine (MD) for postgraduate medical doctors in Sri Lanka. Some of these programmes were available from its inception and have produced many consultants in different fields of study. At present, it is exploring the possibility of

expanding its programmes of study into other sub specialties related to medicine. Bio-Medical Informatics is one such area which was introduced recently.

Another new trend in PGIM course delivery is the introduction of ***on-line*** courses. Although it is still in its infancy, the future holds considerable potential in its expandability as the sole teaching method or as a blended learning component for selected study programmes.

The PGIM, from its inception, has catered to the doctors who want to pursue careers as consultants. It is only recently that it had focused more on middle grade doctors in upgrading their skills by introducing Certificate and Diploma level postgraduate courses. This has generated considerable enthusiasm among both the trainee and trainer community, as it had opened the flood gates to whatever the barriers there were, restricting these doctors pursuing postgraduate training.

In the current educational perspective, when developing a curriculum, it is imperative that the developers make sure they lay down proper goals and objectives, follow recognized and effective teaching methods, guide students to their full potential and assess using proven and valid methods. The time spent in developing such a course is enormous. The endless discussions, countless arguments, hours of consultations by educational experts make this a mammoth task requiring months to years. Even then the curriculum will continue to evolve putting an extra burden on the designers.

In the backdrop of such a massive academic evolution, the necessity to incorporate technology seems to be a prudent suggestion in any part of the world. Already we have seen a lot of technology being used in delivering on-line content and even making use of Simulations in Medical Teaching. Emphasis on incorporating technology in Medical Education was focusing more towards 'post content development phase'. That is to say that, course delivery, assessment and interaction with the students has seen a fair share of technology.

But, the integration of technology in the ID aspect of medical education has seen relatively little or no development at all, both in Sri Lanka and in many other parts of the world. One such technology which is thought to be the future in ID is 'Automation'. Thus, even though Medical Education is possibly one area which has seen very little 'Automation' in the process of ID, the undoubted potential for 'Automation' of Medical Education has never been disputed.

This article hopes to elaborate on the definition of instructional design, the different automation strategies in existence, the advantages and shortcomings of these strategies and how Medical Education could benefit from integrating automation strategies into Instructional Designing for tackling the knowledge expansion, dissemination requirements and lack of pedagogical expertise.

Instructional Designing

It is the process by which instruction is improved through the analysis of learning needs and systematic development of learning materials. A useful concept in understanding what it is all about is the assertion that Instruction is ***"anything that is done to help someone learn", and ID theory is "anything that offers guidance for improving the quality of that help"***[(1)]. The field of ID has been flooded with numerous ID models and concepts which can be made use of in different stages of course designing processes. Although there are many theories available in facilitating the ID process, some argue that the ***designers are either not using these theories in the actual design process or they cannot apply these theories due to its incompatibility in the current educational context***[(2)].

Two approaches have been described in the process of ID. One is the ***Behavioural/Objectivist Approach*** and the other is the ***Constructivists/Cognitive Approach***.

In ***Behavioural Approach*** the theorist expects to achieve immediate, recognizable changes in the behaviour by framing instructional goals in specific, behavioural, observable terms. In this approach, the presence of a criterion on which the success is measured, defines the acceptable level of performance. ***The lacking element in this approach would be the cohort discussions that takes place in other strategies.***

Cognitive Approach on the other hand expects learners to build their own understanding based on their unique experience. Here, the instructional goals are framed in empirical terms, thereby proposing the learner problems, learner control over the environment, activities to be engaged and how these activities can be shaped by the instructor. It further emphasizes the need to reflect and to engage in collaborative learning by the students.

Instructional Design Models (ID models)

Learning from the above approaches, prescriptive models has been developed which are capable of imparting vital Instructional Strategies and sequences for Instructional Designers as well as SME. Some of these models are discussed below.

Algo-Heuristic Theory[3] tries to identify mental processes of expert learning especially the processes which happens without our consciousness. It defines the presence of ***algorithmic problems***, which can be dealt with by formulating precise, unambiguous algorithms and ***heuristic problems***, which cannot be solved by such algorithms. It further emphasize that these problems need instructions that contain certain degree of uncertainty. The theory suggests the use of 'snowballing' as a method of sequencing the instructions, where the first operation is taught and the second operation is expected to be learnt with the first and so on.

ADDIE model describes 5 generic steps used by the Instructional Designers and the mnemonic stands for Analysis, Design, Development, Implementation and Evaluation. Being dynamic as well as flexible, it has become the basis for many other ID models. One such notable addition to the ADDIE model is the process of 'Rapid Prototyping' which ensures feedback at every stage of the development process when the errors are easy to fix.

The Criterion Referenced Instruction [4] is a framework to design and deliver training programmes. In his model, Mager mentions that objectives are supposed to be derived from job performance and reflection on the competencies needing to be learned. He also mentions that students will only practice those skills that are not yet mastered. The students will be given ample opportunity to receive feedback while practicing these objectives and will receive repeated practice on skills that are frequently used or difficult to learn. Finally, the progress is controlled by their own (students) competencies.

Component Display Theory [5] classifies the learning in dimensions. In its basic form it classifies content (facts, concepts, procedures, and principles) and performance (remembering, using, generalities etc) in two dimensions. It elaborates four primary presentation forms as rules, examples, recall and practice. It also mentions several secondary presentation forms as prerequisites, objectives, helps, mnemonics and feedback. The theorist suggests that in order for instructions to be more

effective, it should contain a combination of all primary and secondary forms of presentation. ***It also reminds the fact that for any individual and objective there is a unique combination of presentation forms that results in the most effective learning experience.***

Morrison, Ross and Kemp model [6] lays down 9 steps in the process of ID and similarly ***Dick and Carey model*** [7] defines a similar pedagogic intervention. The Kemp model is highlighted by demonstrating that each component of the model can be handled independently of each other and it is known to provide the designers extra bit of freedom to start anywhere rather than sticking to a sequence. It further emphasizes the need to plan the entire project rather than only the instructional activity. In the Dick and Carey model, though it elaborates a detailed guidance of a systematic ID process, ***the main drawback would be its predefined strategy in arriving at the final outcome which limits the flexibility of instructional designers.***

It is evident from the above illustrations that the ID model used in certain contexts might not be appropriate in a different context. Therefore in selecting the appropriate model for an instructional process, we need to contextualize what is available and what would be appropriate.

Automation in Instructional Designing

In general terms, the word 'Automation', is used when a process has been developed to alleviate the necessity for human interventions. In recent times, Instructional Designing saw its process being facilitated in a wide variety of instances through automation and thus gave rise to 'Automated Instructional Designing' (AID).

What Makes 'Automation' Applicable for ID?

The following reasons were identified as motivating factors for automating the instructional processes. Lack of ID expertise, pressure on designers for more productivity, need to standardize the products and effectiveness of the product were some of these factors [8]. These have been further strengthened by documented evidence such as "AID tools are especially useful in situations where instructional design expertise is lacking and subject-matter experts and others are responsible for developing instruction" [9] and "the ISD (Instructional Systems Development), especially for computer-based multimedia interactive instruction, is too labor intensive, usually requiring more than 300 hours of development for a single hour of instruction" [10].

Attempts at Automating the ID Process?

In developing AID systems, ***an important decision to make is whether to support an ID task or to automate the process*** [8]. There have been several attempts at automating the ID process taking into account the assumption that "instructional knowledge has a generic nature and is representable in a generic model" [10]. Some of these methods or tools make use of "expert's" models / 'Good practices' in ID and others try to comply with the existing practices [11].

In an effort to incorporate technology into the ID process, several approaches could be identified. A***dvisory or Expert, Procedural support, Annotational and Generative*** are some of these approaches [11].

Out of the 'A**dvisory systems'**, the ***'ID Expert'*** is a research project led by David Merrill at the Utah State University and could be considered as one of the foremost research projects in the area of AID. It categorizes itself as a Second Generation Instructional Development System (ID_2). It differentiates itself from the Instructional Systems Development (ISD) model of Robert M. Gagné of Florida State University by being capable of analyzing, representing and guiding instruction to teach integrated sets of knowledge and skills. It is capable of producing pedagogic prescriptions for the selection of interactive instructional strategies and the selection and sequencing of instructional transaction sets. Furthermore, being an open system and being able to incorporate new knowledge about teaching and learning, it is able to apply these in the design process [(12)].

An important concept in this regard is the ***'Instructional Transaction Theory'*** [(13)]. It has been the basis for the ID Expert work flow and demonstrates the ability to represent the interaction done by a learner in acquiring the knowledge and using a transaction. It is more of an algorithm that designates how the learners should interact in acquiring a certain skill using a given set of knowledge. The basic component of this theory is the 'Transaction Shell' which contains an authoring environment and a delivery environment. The knowledge acquisition component of the authoring environment queries the designer on relevant knowledge and skills required for the enterprise. A transactional configuration component of the authoring environment allows the designers to set instructional parameters. Based on this it will interact with the students.

Another advisory system that helped in research concerning AID is the ***Expert CML (Expert Computer Managed Learning Project)***. This system has distinct features compared to the ID Expert, namely, ***it only suggest to the users on instructional techniques on request or when a gross violation of such techniques were done by the user; the user has the ability to override the advisory system; it follows a top down strategy of course designing which also includes a student monitoring system which allows the users to evaluate the course based on student performance; it is designed for online curricular and course designing as well as student monitoring.***

In a medical educational context, both systems feature commendable strategies which can be applied if such a tool is to be developed. But, ***being designed for computer based academic programmes and being restricted in incorporating teachers experience in the ID process, along with inability to cope with a large curriculum***, it limits its ability to directly intervene in the ID process in such an environment.

The term '***Procedural Support Tools'*** was used by Goodyear to label the computer based tools which provides a structure for the designers to work with and which does not provide any expert instructional advice on how to do that process. Although it might help in producing a consistent output, the effectiveness and the quality of the output will be questionable.

The classification under '***Annotational Systems'*** includes the Instructional Design Environment (IDE) developed by Xerox Paulo Alto Research centre[(14)]. The basic concept of such a system according to Goodyear, is the ability of such a system to record the design process and keep track of what took place and in turn help the designers to reuse these elements or concepts repeatedly as well as to coordinate between other designers on changes affected and its basis. Unfortunately, the drawback of such a system is that it does not cater to a 'Novice Designer' in producing quality instructions.

'Generative Systems' on the other hand are systems which take over some of the work done by the instructional designer as well as the instructor. ***Intelligent Tutoring Systems (ITS)*** is an example of

such a system. In summary these systems will have an ***interface, student module, expert module and a tutor module.*** These systems try to identify gaps in learning by measuring the deviation of learners from ideal learners and try to apply tutor behaviour expected in such situations to rectify the problem. ***Limitations seen in these systems are due to the high cost involved in the development of such a tool, limiting itself to computer based tutoring, inability of the novice instructional designers to apply their experience as a design principle and near zero human participation in the tutoring process.***

When various approaches in the process of instructional designing is considered, it draws out the fact that even though these concepts are based on a generic design, when automating the instructional process, it should take into account the context in which the system is going to perform.

Automation of ID in the Context of Medical Education

In order to identify possibilities and probabilities of integrating automation of ID in medical education, it is useful to identify some of these theories and existing practices in teaching medicine.

Organizing the curriculum and lesson planning has been described using 10 questions by Ronald Harden[15]. The questions focuses on needs analysis, developing aims and objectives, identifying the content, organizing the content, educational strategies to incorporate, teaching methods to use, laying down assessment methods and criteria, communication of the curriculum among stake holders, deciding on the educational climate and managing the whole process.

Given the nature of the above steps, it is prudent to assume that a ***'procedural support tool'*** with a ***structure similar to Hardens 10 questions*** would be able to make the users think in this line prior to developing a curriculum. Each step of the sequence can be supported by different assist tools as described below with each step. The same sequence can be followed from planning of the curriculum to planning of the lesson materials.

As with any educational strategy used in ID, Hardens 10 questions begins with a ***Needs Analysis.*** Different approaches have been described in identifying these curriculum needs[16]. The Subject Matter Experts (SME) or the clinicians in Medical Education would be capable of identifying what is required from a student in becoming whom they are expected to be. A software module capable of capturing the user input as characteristics of students and presenting the instructional strategy accordingly would ideally be assisting the designers as depicted in ***ID Expert***[13].

Next question guides the designers to develop the ***Aims and Objectives*** for the curriculum, much in the same way as the 'Design phase' of the ADDIE model of instructional design. The use of Blooms Taxonomy[17] and its modified versions are widely practiced in defining objectives of a Medical Curriculum. Due to the extensive nature of the list of objectives and the usual classification of knowledge, skills and attitudes not representing clinical practice, these objectives were somewhat ignored in planning and implementation of a Medical Curriculum[15]. Thus, an automated system should be ideal in tackling these problems as it can guide the users in effectively deciding on learning objectives as well as to follow it up throughout the curriculum planning and implementation process. The ***'Advisory system' Expert CML,*** provides an effective means of giving support to the users without limiting their use of expertise in the subject area and promoting creativeness in a 'non threatening' manner. The ability for a software tool to give suggestions on naming the objectives appropriately, would overcome the initial design errors that would be created if over ambitious, non measurable and irrelevant outcomes and objectives were to be defined.

Following this, the actual content is recognized and is organized. In an ID system, the phase in which the ***content is organized*** plays a pivotal role. In view of its importance for a Medical Curriculum, a 'Spiral Curriculum'[18] was introduced facilitating revisiting of topics, along with gradual difficulty levels in revisited topics. ***'Knowledge objects' introduced in the 'ID Expert'***[10] will provide a software system with the ability to chunk the available content, with different instructional strategies for each visit of the student and appropriate linkages, with other relevant objects. These objects should not necessarily be organized to cater to a computer based multimedia interaction, but rather to cater to a repository of knowledge and relevant instructional components to facilitate it to be used as 'RLO's or ***Reusable Learning Objects***. According to the IEEE Learning Technology Standards Committee IEEE P1484.12.1-2002 Learning Object Metadata Workgroup, the RLO is defined as "any entity, digital or non digital, which can be used, reused or referenced, during technology supported learning". Ideally, the RLO's should, consist of a single objective which is context free, interactive, self descriptive, self contained, single sourced and format free. Therefore, automation of medically related Instructional Designing would benefit from such a RLO based structure in its content organization[19].

Next, with a method of content organization at hand, Harden asks to decide on ***educational strategies*** in handling needs, content and intended aims and objectives.

In planning a medical curriculum, it is of best interest to decide on where the existing curriculum stands in an educational perspective or what strategy that are going to be used for a new curriculum. The SPICES model[20] gives valuable insight into what domains exist in the Medical Curriculum needing application of different educational strategies in moving ahead. They identified six domains and each has been described as a continuum. It also explains that newer developments in Medical Education are towards the left of the model whilst the traditional ways of teaching is towards the right.

S Student-centred ---------- Teacher-centred
P Problem-based ---------- Information-gathering
I Integrated ---------- Discipline-based
C Community-based ---------- Hospital-based
E Electives ---------- Standard Programme
S Systematic ---------- Apprenticeship-based

Spices model [20]

The usability of the SPICES model in ID pertaining to Medical Education is that it demonstrates the areas on which 'Educational Strategies' should focus its attention. It also explains what strategies can be adopted in moving towards more effective means of training the students in current theoretical context. As discussed earlier, adopting the ***advisory aspect of the 'Expert CML'*** would assist the users in arriving at a decision on what path to be chosen in any given domain in the SPICES model. This will have to be in cohesion with the teaching strategies that is to decide next.

Once the educational strategy is in place, the curriculum designers need to decide what the ***teaching strategies*** are for each of the learning domains. Medical Curriculae around the world are flooded with various forms of teaching methods and some of them are Problem Based Learning, Task Based Learning, Small Group Discussions, Fixed Learning Modules, Integrated Ward Classes, Ward Classes, Skills Lab, Simulations and Electives etc. ***The above mentioned RLO's will be able to provide the users with appropriate strategies in teaching*** its content and a advisory system will further assist in choosing the best.

The assessments take various forms and it should measure whether the students have achieved the expected outcomes of that course. If an RLO based system was designed, by this stage the users will be able to acquire from the system the best possible assessment tool. Out of the many different assessment tools, Objective Structured Clinical Examinations (OSCE), Oral examinations, Structured Essay Questions (SEQ), Modified SEQ, Multiple Choice Questions, Extended Matching Items are some of the possibilities thsat may be entertained. The choice of the assessment tool will be influenced by the level of assessment possible or deemed possible by each assessment tool. The Miller's 'pyramid of competence'[21] illustrates the levels at which clinical competencies should be assessed and what tools can be used at each level. ***The Knows, Knows how, Shows and Does*** is a possible classification of various assessment tools and the user should be able to match the appropriate level of assessment that is required in an ID assist tool. Harden in his 10 questions suggests answering the following questions in order to prepare an effective assessment.

- What should be assessed?
- How should it be assessed?
- What are the aims of the assessment process?
- When should students be assessed?

and

- Who should assess the student?

If integration took place between automation and ID designing in Medical Education, by this stage the users of such a system would be able to obtain an ***Assessment Blueprint*** based on the outcomes and the topics that were defined in the initial stages of the process. Modifications of the blueprint as well as advice regarding best practices in assessments will be provided to the user in such a system. ***If the RLO's are capable of suggesting the ways in which each given objective should be assessed this will be a less complicated and a systematic task.***

Failure in ***communication between teacher and student*** is a common problem in medical education[15]. As was said earlier, the integration of technology into Medical Education should propagate sharing of information between all parties concerned with a curriculum. In PGIM, the Instructional Development for a particular course is done by Subject Matter Experts who are based in different Hospitals, Universities and Institutes. Several subject matter experts may be involved in the designing process and the communication between them is more of a verbal explanation from one another than a constructive analysis. ***A web based design assist tool*** would be an opening to relevant designers as well as others who are interested in the development process to communicate and share their views and work towards a common goal. Being an electronic curriculum, constructing a means to communicate details about the curriculum to the students would be another paradigm and can be in the form of a Study Guide or a Curriculum Map.

As Harden suggested, answering the question of 'Educational Environment' would be a challenging task for an automated system. Being a flexible instructional environment, the suggested assist tool will be able to promote the users in properly laying down the initial objectives, outcomes and follow up instructions suited to the environment that it is going to be implemented in. Thus a separate intelligent module to align the curriculum according to the environment deemed unnecessary. As discussed earlier, the overall management of the curriculum will happen automatically through the proposed design assist tool.

Conclusion

It would be evident from this discussion that one approach might not be suitable in the process of automating the ID process in Medical Education. Therefore, a combination of existing automation approaches would fit the context of Medical Education and such an approach would consist of features such as guidance of the SME through theoretical information and possible alternatives following advisory system behaviour, creating a repository of knowledge objects with appropriate instructional strategies and assessment methods based on RLO's, sharing of RLOs among SME in different programmes of study, generating Assessment Blueprints, Study Guides, Curriculum outlines and RLO based Preliminary Instructional Materials and finally, learning tools for SME in Instructional Designing.

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