Hindawi
Journal of Biomedical Education
Volume 2018, Article ID 4268517, 5 pages
https://doi.org/10.1155/2018/4268517

Review Article

Applying ADDIE Model to Ideate Precision Medicine in a Polytechnic Biomedical Science Programme

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Received 27 February 2018; Revised 24 April 2018; Accepted 17 May 2018; Published 10 June 2018

Academic Editor: Friedrich Paul Paulsen

As a biomedical science programme at polytechnic aims to provide a sound foundation in the biological sciences, the onus is on the curriculum developer to see that the relevance and currency of the programme content are justifiably challenging and work-ready. In other words, the programme needs to prepare its students adequately well for the intended industry. Since the inception of Human Genome Project, the molecular paradigm has been evolving. A biomedical science student who is oblivious to the emerging trend in molecular techniques is very likely to be hearkened back to the yesteryears of technology and bewildered as precision medicine is becoming increasingly important. Using the ADDIE model as the instructional design model, this paper describes the roadmap for creating a molecular techniques module within a diploma programme that percolates with the concept of precision medicine.

1. Introduction

As the implications of genetics and genomics have gained considerable roles in all aspects of patient care [1], precision medicine has emerged to be a biofantasy coming true in terms of its utilisation in devising medical interventions or preventive strategies that are personalized to an individual's pathophysiological conditions [2]. Many sophisticated technologies have also been innovatively developed to enable the practice of precision medicine [3]. On a similar note, promising clinical utility of precision medicine is also evident in literatures [4]. Undoubtedly, precision medicine has its transformational role in converging biomedical science, physical science, and engineering research for the promotion of health care strategies that are individual-centric, data-driven, and mechanism-based [5]. To ensure that biomedical science polytechnic students are not deficient in the emerging area of genomics in laboratory medicine, inclusion of a relevant molecular diagnostic module is inevitably necessary. Yet, in polytechnic, to ideate the concept of precision medicine to a cohort of postsecondary students with no prior exposure to Molecular Pathology Techniques is constructively challenging as constructivism theory posits that the learning of novel information is to be contextualised with prior knowledge and personal experience [6].

In view of this situation, the ADDIE instructional design model was explored to devise programmes of instruction [7]. The purpose of an instructional design model is to offer design steps, management guidelines, and options for the organisation of teaching and learning materials in an optimised manner that is suited for the learning process of the learners. Here, contextualising the use of the ADDIE model is cogitated on infusing the concept of precision medicine into our polytechnic biomedical science education. Using the five phases of ADDIE model, namely, analysis, design, development, implementation, and evaluation, a structural approach is engaged in reviewing the learning materials from various perspectives.

2. Background

Our polytechnic biomedical science programme is designed to prepare students to be gainfully employed in the field of biomedical sciences. Consequently, a good understanding of the core life-science subjects and biosafety is essential. With the advent of innovative technologies, the magnitude of information gained through a myriad of experimentations has grown by leaps and bounds over the past few decades. In particular, the advances of genetics and genomics have not only transformed the paradigm of biology [8] but also

Table 1: The five phases of ADDIE.

Analyse	To analyse and clarify a learning situation so that the instructional goals, objectives as well as learner profile & needs are established
Design	To design instructional methods to address the issues in the learning situation
Develop	To develop instructional resources that align with strategized learning process
Implement	To implement instructional system in the learning situation
Evaluate	To evaluate whether the instructional system indeed addresses the learning situation

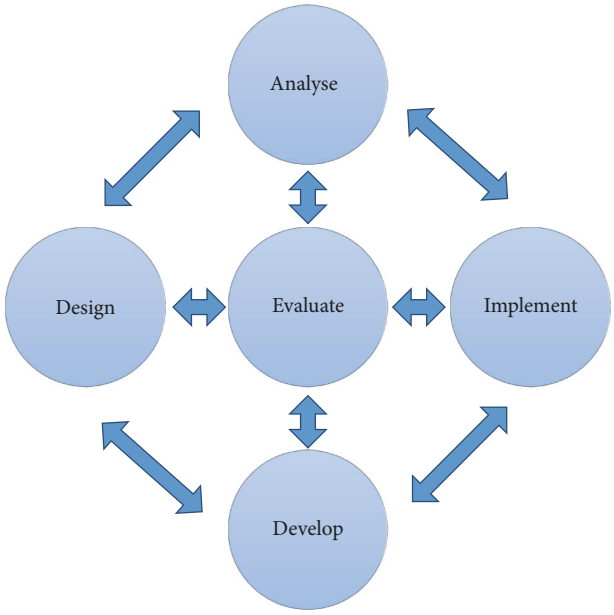

Figure 1: The nonlinear ADDIE process.

provided the basis for health, illness, disease risk, and treatment response [9]. Discernibly, biomedical science students cannot be deficient in genetics knowledge and its application. Therefore, module like "Cell and Molecular Genetics" is introduced in the Year 1 curriculum of our biomedical science programme for fundamental understanding. In Year 2, Molecular Pathology Techniques module is emplaced in the curriculum to emphasize the use of molecular techniques to diagnose or monitor diseases. With the aim of infusing the concept of precision medicine into the module of Molecular Pathology Techniques, we applied the ADDIE model to address our learning outcomes as well as instructional design and development. While the five phases of ADDIE model appear to be a linear process of analysis-design-development-implementation-evaluation (Table 1), it is noteworthy to be mindful that the ADDIE model is a continuous process (Figure 1) with each phase being able to interact with one another in a toggling manner [10]. Here, for the ease of flow and clarity, the five phases of ADDIE model are sequentially presented.

3. ADDIE in Action

3.1. For Analysis. We started the analysis phase by identifying our learners' profile, learning outcomes, learning environment, and stakeholders' expectation. While stakeholders can be defined as polytechnic students, parents, teaching staff, employers, and further education institutions, we placed substantial emphasis on employers as polytechnic education seeks to equip students with relevant skills for the workplace [11, 12]. Within a polytechnic academia, we are cognizant of the leaners' profile and learning environment. Thus, the need to determine the expectations of a laboratorian working in a molecular diagnostic laboratory is critical as this will inform about the scope of learning outcomes. With information gathered from industry standards [13, 14] and stakeholders from local hospitals, we recognized the skills, knowledge, and abilities that the learners need to have in order to complete the job tasks in the workplace. These pieces of information guided the construction of the learning outcomes and set the next phase of ADDIE process-design-going.

3.2. For Design. As the learning outcomes are identified, a detailed plan of instruction is deliberated to create a holistic approach to constructive alignment of learning activities with learning outcomes and blueprinting of assessment strategies with learning outcomes. A variety of instructional methods have been employed, and these include large-classroom lectures, e-learning modules, small-group discussions, and laboratory-based practical sessions. Table 2 shows how constructive alignment and blueprinting can be achieved for the stipulated learning objective of nucleic acid isolation from clinical specimen. At this stage, it is clear to us that we face the pragmatic concern of what is good to know versus what is needed to be known in our syllabus. To move forward, we keep in mind the role and the job grade that these learners will be employed as and at, respectively, upon polytechnic diploma graduation [13]. This sensing has certainly helped us in focusing the curriculum of molecular diagnostic technology [15, 16].

3.3. For Development. In the development phase, we came up with lesson plans and lesson materials based on the learning outcomes developed in the design phase. The content created for large-classroom lectures is largely didactic. As we aim to ideate the concept of precision medicine in the Molecular Pathology Techniques module, we purposefully introduce the controversial case of Angelina Jolie (Figure 2) for case discussion [17]. At present, we also plan to introduce the implications of direct-to-consumer (DTC) genetic test in small-group discussion activity (Figure 3). The intent of such discussion is to address the contestable issues of DTC genetic tests [18–20]. In addition,

Table 2: An example of instructional methods to accomplish learning and assessment activities.

Learning outcome	Learning activities	Assessment methods
Will be able to perform nucleic acid isolation from clinical specimen.	To introduce standard operating procedure (SOP) used in clinical laboratory in a didactic lecture.	Written assignment: To write a SOP for blood collection for genetic testing.
	To learn the technique of DNA isolation from blood specimen in a laboratory-based practical session.	Laboratory write-up: To write a report on the quantity and quality of the DNA isolated.

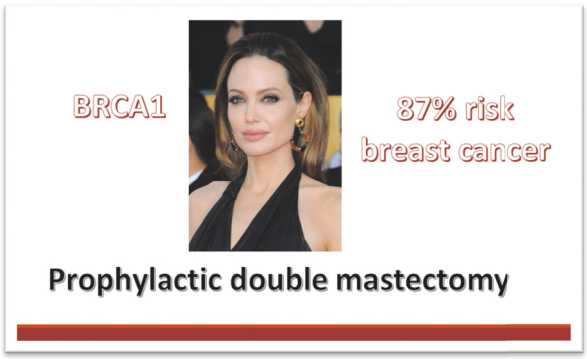

Figure 2: Discussion of Angelina Jolie's case.

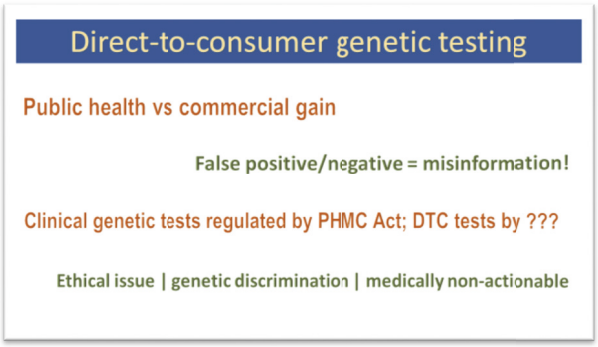

Figure 3: Discussion of direct-to-consumer genetic testing.

the ethical aspects on testing for complex diseases would also be deliberated, especially on the implications of insurability and employability, incidental findings, and medical actionability [19, 21]. On the other hand, we also present a video on pharmacogenomics from the Mayo Clinic (https://www.youtube.com/watch?v=Qog5Dr9u-nA). This video has not only helped us in capturing the attention of our learners but also exposed them to a succinct overview of pharmacogenomics. As gene detection is an essential step in precision medicine [22], a series of experimentations involving nucleic acid isolation from clinical specimen, nucleic acid amplification via polymerase chain reaction, and restriction enzyme mapping activities is also utilised for low-cost academic exercises. To avoid confounding medical issues, the status of lactase persistence [23] is chosen for case discussion in laboratory-based practical sessions. Students are encouraged to critique the results they have obtained and to discuss the congruence or discrepancy of any clinical symptoms that they are aware of from the interview findings with DNA volunteers [24]. Pedagogically, such activity intends to engage students' linguistics as well as intrapersonal and interpersonal intelligences [25].

While operational cost is a discerning factor in running practical sessions, the curriculum has endeavoured to include real time polymerase chain reaction, single nucleotide polymorphism profiling, and next generation sequencing technology [22] for authentic learning experiences within the research facilities in polytechnic premises. The selection of these molecular techniques concurs relatively well with the survey results reported by the Medical Laboratory Scientist Curriculum Task Force of the Association for Molecular Pathology [16]. Recently, the magnitude of research works and talking points revolving around genome editing technology is growing enormously [26–30]. On this note, we acknowledge the impetus to include such a topic of genome editing technology in our curriculum and we are currently deliberating how best we can incorporate CRISPR-Cas9 technique into the module Molecular Pathology Techniques while keeping the running costs manageable [31, 32].

3.4. For Implementation. In this phase, the crafted learning materials are deployed for implementation. Under operational conditions, it is important to identify the gap in constructive alignment and blueprinting in assessment [33]. Clearly, the instructional gate keepers like faculty members need to be in sync with the instruction system and learning outcomes. Any feedback with regard to the implementation plan should be duly collated to inform the next phase of ADDIE: evaluation.

3.5. For Evaluation. As mentioned previously, the ADDIE model is a continuous process (Figure 1). Hence, evaluation should also be regarded as a continuous process starting from the analysis phase and continuing throughout the four phases of ADDIE. An initial formative evaluation of the instructional program should be conducted in the analysis and design phases to assess how well the learning outcomes were met using various instructional methods. This can be done by gathering feedback from teaching faculty and practicing educationist from the educational department during sharing sessions. While operational evaluation can be garnered from feedback provided by students and teaching faculty during course delivery, it is critical to sieve out information that informs about the discrepancies between planned and actual delivery of instruction programmes. Obviously, the feedback must be treated with incremental improvement in mind. We are gratified to see a positive change in feedback collected

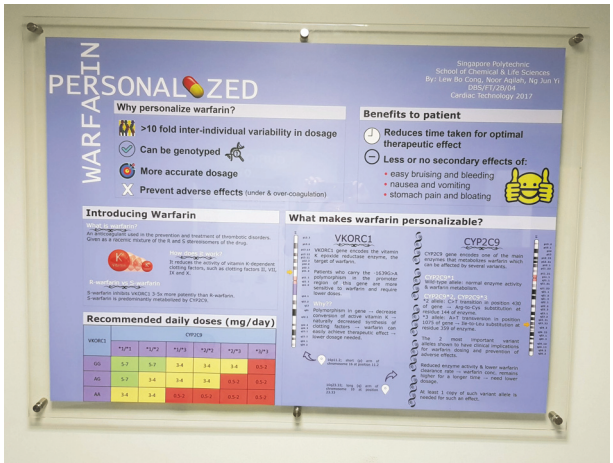

Figure 4: Student poster presenting Personalized Warfarin.

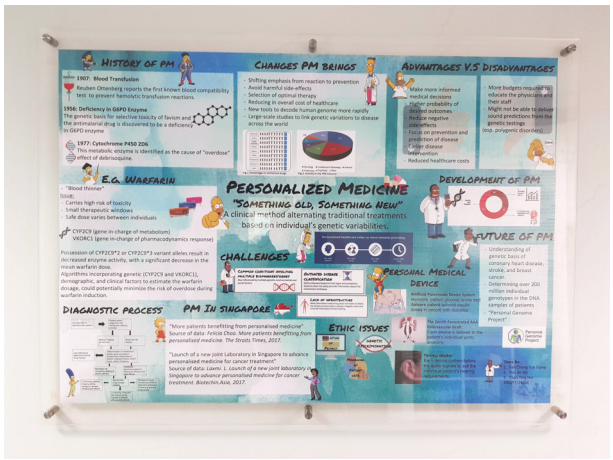

Figure 5: Student poster presenting Personalized Medicine.

over three runs of the Molecular Pathology Techniques module. From daunting remarks like "*Answers for lab assignments are hard to find in both books and online resources*" and "*Some of the content was very confusing and hard to understand*" to reassuring comments like "*Most of the practicals were very well explained and related to the [taught] topics*", "*Practicals had good connections to one another*", and "*The whole module is very cohesive*", this exemplifies the process of analysis-design-development-implementation-evaluation which aids in managing and enhancing the programmes of instruction. With poster assignment incorporated in another module, Basic Pathology, students were able to synthesize interesting topics in Personalized Medicine for presentation (Figures 4 and 5). This demonstrates that the intent of ideating the concept of precision medicine in the biomedical science programme is well-received.

4. Conclusion

Applying the ADDIE model for the development of instructional programmes is a good way to organise teaching and learning as it provides a systematic approach. While it may seem to be eminence-based and historically rooted in instructional theory, its usefulness in developing education and training programmes is still evident in the 21st century [34–37]. Using the five phases of ADDIE, we have constructed relevant learning materials for a polytechnic biomedical science programme that percolated with the concept of precision medicine. Perhaps, with the advent of ever-advancing technologies and emerging new knowledge, the use of ADDIE five phases will be an ongoing effective way in keeping our curriculum in currency.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this paper.

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