Using Core Competencies to Develop a Bioinformatics Training Programme

Nicola Mulder
University of Cape Town

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Pan African Bioinformatics Network for H3Africa

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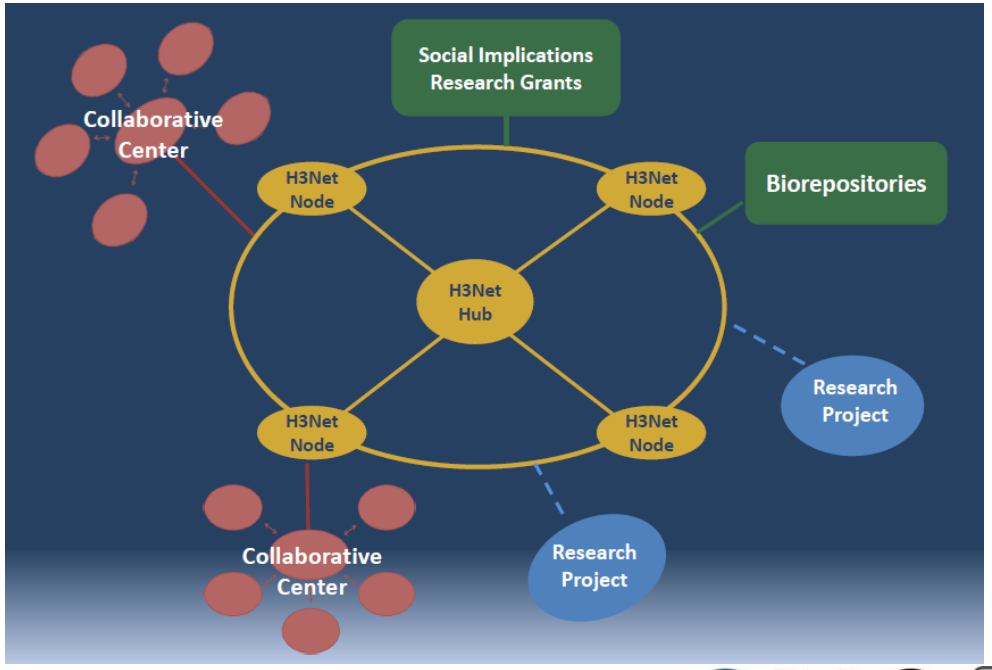
Outline

- Background –H3Africa and H3ABioNet
- Bioinformatics and related training:
  - Bioinformatics Masters degree
  - Introduction to Bioinformatics course
  - Genomic Medicine training

What is H3Africa?

"The Human Heredity and Health in Africa (H3Africa) Initiative aims to facilitate a contemporary research approach to the study of genomics and environmental determinants of common diseases with the goal of improving the health of African populations. To accomplish this, the H3Africa Initiative aims to contribute to the development of the necessary expertise among African scientists, and to establish networks of African investigators."

www.h3africa.org



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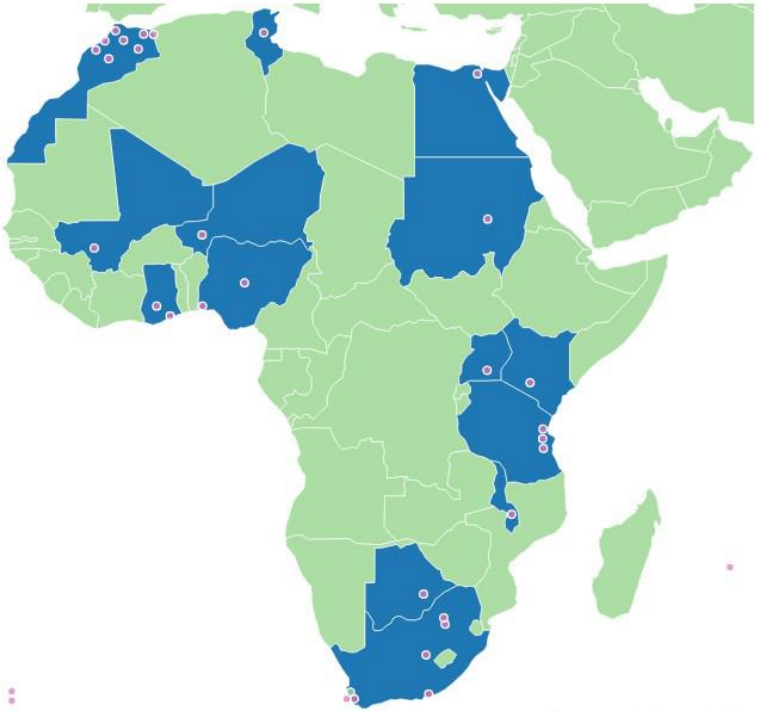
What is H3ABioNet?

- Pan-African bioinformatics network to develop bioinformatics capacity to enable genomic research in Africa.
- H3ABioNet has 32 institutions in 15 African countries, 1 in USA and 1 in UK
- www.h3abionet.org



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Who do we need to train?

- H3Africa consortium
  - >$76 million
  - 25 projects, >500 investigators
  - 27 African countries
  - Nurses, study coordinators, geneticists, clinicians, data analysts
- H3ABioNet consortium
  - >$12 million
  - >120 people
  - Bioinformatics users, scientists, engineers

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Genomic Medicine

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  - >120 people
  - Bioinformatics users, scientists, engineers

Intro to Bix

Bioinformatics MSc

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Need for MScs in Bioinformatics

- Only a handful of MSc in Bix outside SA
- Many institutions wishing to establish programs
- Held Bioinformatics curriculum development workshop in Botswana
- Established African Bioinformatics Education Committee (ABEC)

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ABEC

- http://www.h3abionet.org/training-and-education/african-bioinformatics-education-committee
- Curriculum development task force
- Set up website with guideline documents:
  - Considerations –key steps for starting a program
  - University processes for developing new programs
  - Existing programs and curricula
  - Curriculum development

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H3ABioNet Bioinformatics curriculum

- Set of core and elective modules for a bioinformatics program using the ISCB guidelines have been defined
- Based on discussion, needs of individual institutions and existing curricula
- Trainers determined the content and contact hours for these modules
- Have included suggested lecturers from Africa
- http://training.h3abionet.org/curriculum_development_wg/

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H3ABioNet Bioinformatics curriculum

H3ABioNet Curriculum Development Taskforce

H3ABioNet taskforce to develop a curriculum of bioinformatics to be used throughout the continent

HOME | BIOSTATISTICS I | DATABASES I | DATABASES II | ETHICS | EVOLUTION AND PHYLOGENETICS | GENOMICS AND COMPARATIVE GENOMICS | HIGH-THROUGHPUT SEQUENCING | INTRODUCTION TO LINUX AND SHELL SCRIPTING | INTRODUCTION TO PROGRAMMING FOR BIOLOGISTS | MACHINE LEARNING | METABOLOMICS | MOLECULAR BIOLOGY FOR PROGRAMMERS | POPULATION GENETICS AND GWAS | PROGRAMMING I | PROGRAMMING II | PROTEOMICS | SEQUENCE ANALYSIS | STATISTICS II | STRUCTURAL BIOINFORMATICS | WG MEETING MINUTES | WRITING & PRESENTATION SKILLS

H3ABioNet Curriculum Development Taskforce

In the wake of the Gaborone Workshop (H3ABioNet / University of Botswana, March 11th-12th 2014), H3ABioNet decided to build a taskforce to develop a standard curriculum in bioinformatics, at the MSc level.

This site is the repository for the documents produced by this Curriculum Development Task-Force (CDTF), and primarily for the module outlines as proposed by the CDTF members.

Please find here the different modules proposed and the list of volunteers for these. The menu on top of this page provides links to the different outlines.

The meeting minutes are to be found on this website, here (tab "WG Meeting Minutes" on top of this page).

Search

RECENT POSTS

H3ABioNet Curriculum Development Taskforce

RECENT COMMENTS

Benjamin Kumwenda on Databases I
Amel Ghouila on Sequence Analysis
Amel Ghouila on Databases I

Example module page

Module outline by the H3ABioNet Curriculum Development Taskforce

Biostatistics I

2014-03-06 07:03:32 Jean-Baka Domelevo Entfellner

Prepared by: **Jean-Baka Domelevo Entfellner**
Possible Lecturers: Jean-Baka Domelevo Entfellner, or any bioinformatician with a strong background in mathematics and statistics, ideally from his/her primary education.
Contact hours: For consistency reasons, each contact hour is fixed at 45min.
Theory (23), Practicals (30)

SPECIFIC OUTCOMES ADDRESSED

1. Generally speaking: develop an understanding of stochastic experiments
2. Understand and be able to build the framework of a statistical test

BACKGROUND KNOWLEDGE REQUIRED

Basic general-purpose scientific knowledge, basic arithmetic skills, and some familiarity with basic linear algebra.

BOOKS & OTHER SOURCES USED

1. Fundamentals of Biostatistics, 7th edition, by Bernard Rosner (Cengage Learning, 2011)
2. Biostatistics with R — An introduction to statistics through biological data, by Babak Shahbaba (Springer, 2012)

COURSE CONTENT

(A) Theory lectures

I. Probability theory:
1. Atomic and complex events, probabilities as a measure on sets,

Example module page

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Curriculum Development Ta

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COURSE CONTENT

(A) Theory lectures

I. Probability theory:
1. Atomic and complex events, probabilities as a measure

3. Enumerative combinatorics: counting permutations, combinations and partitions. Binomial coefficients.
4. Some common discrete probability distributions: Bernoulli, binomial, Poisson. Behaviour of a binomial when the number of trials tends to infinity. Concepts: probability mass, expectation of a discrete distribution.
5. First continuous probability distributions: uniform, exponential
6. Central limit theorem and the normal distributions

7. Other continuous distributions: Student's t and chi-square distributions.
II. Statistical hypothesis testing
III. Analysis of variance and regression models
IV. Multidimensional dataset analysis: Principal Component Analysis

(B) Practical component

We suggest the use of Rstudio throughout the course, as an integrated development environment to work with R. Being the fundamental statistical software in use across various research areas, it is essential that the students develop mastery over R during this course.
Alternatively, if computing resources are extremely scarce, use an interactive R interpreter to demonstrate the concepts, plus a simple text editor later on, once the students start writing functions.
This section "practical component" follows the same structure as the previous section "Theory lectures": practicals just aim at having the students manipulate the concepts seen in the lectures, right after they were introduced to them.

ASSESSMENT ACTIVITIES AND THEIR WEIGHTS

We would suggest two written exams during the course of the module (total weight = ½) , and a final programming exam (weight = ½). Of course, practicals can also be for marks all along the module, but our advice is not to make each and every practical for marks, not to put too much counter-productive stress on the students. Practicals are the privileged moments when students actually understand the concepts as they put them into play.

Core competencies

- For bioinformatics scientists and engineers we are mapping ISCB core competencies to curriculum

Competency	Bioinformatics user	Bioinformatics scientist	Bioinformatics engineer
User competencies			
Apply knowledge of computing appropriate to the discipline	WK	WK to S	WK
Apply knowledge of biology appropriate to the discipline	S	WK	WK
Ability to use current techniques, skills, and tools necessary for computational biology practice		WK	
Understanding of biological data generation technologies	WK	WK to S	
Understand the limitations of bioinformatics tools		A	WK to S
Scientist competencies			
Use a computer-based system, process, component, or program to meet needs		A to WK	
Evaluate ability of a computer-based system, process, component, or program to meet needs	WK	WK to S	WK to S
Apply statistical research methods in the contexts of molecular biology, genomics, genetics research		A	
Knowledge of general biology, in-depth knowledge of at least one area of biology		N/A to A	X
Appreciation of algorithms to make informed decisions on their suitability to solve a research problem	S	A to WK	
Engineer competencies			
Analyse a problem, identify and define the computing requirements appropriate to its solution		N/A to A	WK
Design and implement a computer-based system, process, component, or program to meet needs	WK	WK	X
Apply mathematical foundations, algorithmic principles, and computer science theory in the modelling and design of computer-based systems		N/A to A	
Apply design and development principles in construction of software systems of varying complexity		A	
Generic competencies			
Function effectively in teams to accomplish a common goal	S	A to WK	
Understand and uphold professional, ethical, legal, security, and social issues and responsibilities		A to WK	WK to S
Communicate effectively with a range of audiences, including, other bioinformatics professionals	S	WK	
Analyse impact of bioinformatics and genomics on individuals, organizations, and society	WK	A	
Engage in continuing professional development		WK to S	
Detailed understanding of the scientific discovery process and of the role of bioinformatics in it		WK	

A: Awareness: the professional appreciates what is possible in this area and how the area impacts on their own work

WK: Working knowledge: the professional has a firm underpinning knowledgebase in this area and applies it effectively in his or her day-to-day work

S: Specialist knowledge: the professional actively contributes to advancement of the area, generating new understanding or new technology

Implementations

- First MSc in Bioinformatics program launched at the University of Bamako this year, lecturers local and distant
- New progam in Malawi just been approved
- Other MSc in Bioinformatics programs such as in Kenya, Tunisia are being developed using the defined modules
- Using some as a base for Introduction to Bioinformatics course

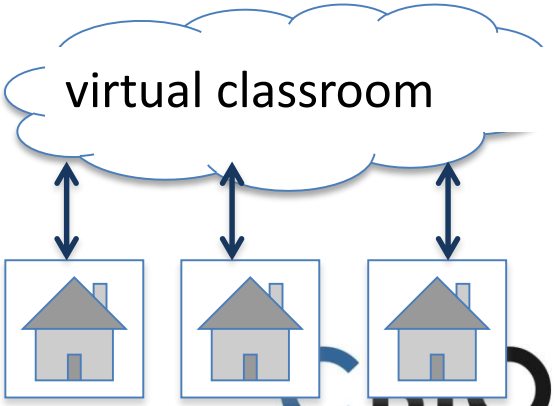
Intro to Bioinformatics for Bix users

Aim

- Basic bioinformatics training for interested H3Africa members (**bioinformatics users**)
- bioinformatics tools, algorithms and resources and how to use them

Course logistics

- 6th July 2016: **3 months**, **2 days** contact time **per week** (**3 hours** per contact session)
- **Distance learning** model – physical classrooms connected to virtual classroom
- Mconf – video conferencing
- Vula – course management



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Intro to Bioinformatics course

Curriculum modules

- Resources and databases
- Linux
- Sequence alignment theory & applications
- Multiple sequence alignment
- Molecular evolution and phylogenetics
- Genomics
- Protein Structural Bioinformatics

Lecturers & teaching assistants mostly from Africa
20 classrooms, 350/550 applicants

Each module is mapping core competencies to content

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Genomic Medicine Curriculum

- Identified need for and interest in genomic medicine training
- Aim to establish a comprehensive, adaptable and coordinated Genomic Medicine Curriculum and Training plan for Africa
- Developing set of competencies for each target audience (nurse, clinician, scientist, lab technician, policy makers)
- Using Kern's Six Step Approach in Curriculum Development

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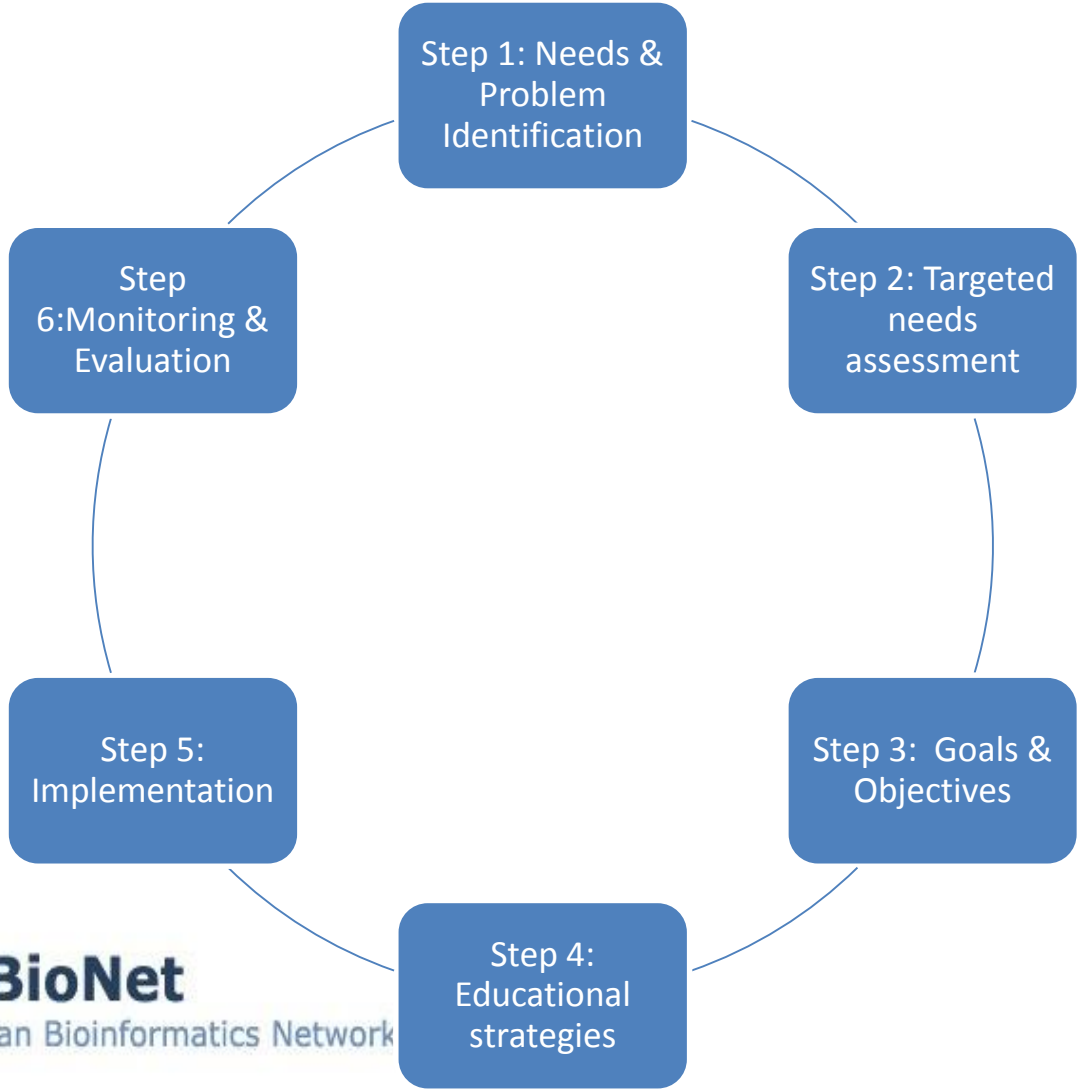
Kern's Six Step Approach to Curriculum Development



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Step 1. Problem identification

- Limited knowledge on how genetics and genomics contribute to disease in Africa.
- Limited learning opportunities which make use of African-specific case studies and diagnostics
- Limited curricula in Africa which sufficiently address genetics, genomics and emerging technologies

Step 2: Target Learners & Needs

High school learners, Patients and affected families & Journalists

Public Education

Podcasts

Online-based platforms

Healthcare professionals & researchers

MSc Courses

Undergraduate modules

Professional Development Course

Pharmacists; Nurses; Medical Doctors; Laboratory technologists; Genetic Counsellors; Clinical trial & Study Coordinators; Pathologists; Ethics Committees; Community Health Care; Workers

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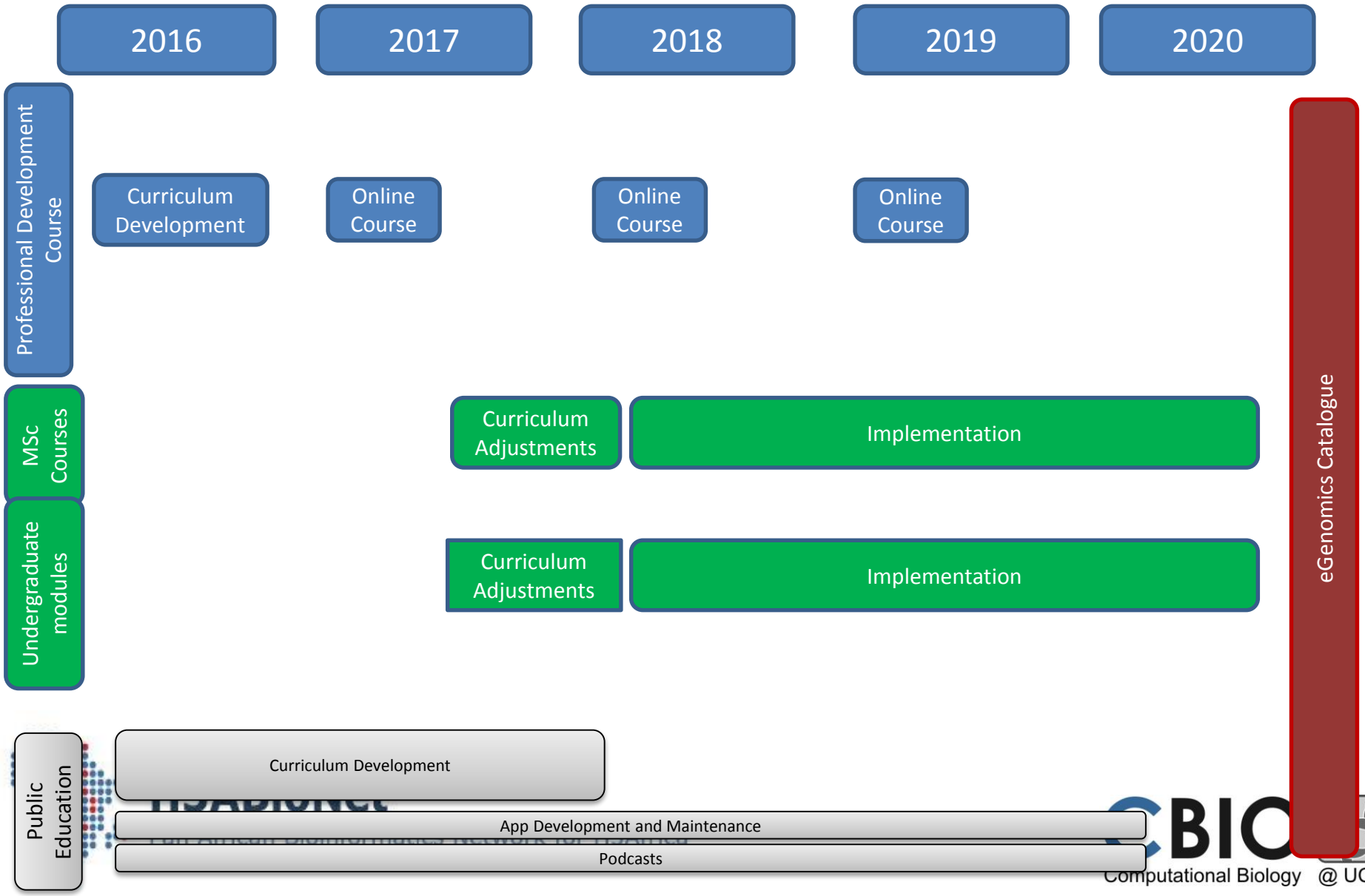
Step 3: Goals & Timelines



Step 4: Educational Strategies

- Case-based approach
- Blended learning – Professional Development Course
- Competency based learning

Step 5: Implementation

- African Genomic Medicine Curriculum Committee
- Small planning committee
- Independent review committee

Step 6: Evaluations

Factors	Evaluation question
African Genomic Medicine Curriculum Committee	Change in knowledge, attitudes, practises in curriculum development
Professional Development Course	Impact of Genomic Medicine Professional Development Course
Healthcare professionals learners	Change in Knowledge, Attitudes and Practises in Genomic Medicine amongst Healthcare Professionals.
African Genomic Medicine Curriculum Committee & Tertiary institutes	An inventory of Genetics & Genomics training and curricula in institutes of higher learning in Africa.
Healthcare Facilities & Laboratories	An inventory of Genetics & Genomics resources and current practices in
Genetic/Genomics Diagnostic tests	Transferability of existing diagnostic platforms and tests to African populations
Public	Feasibility and acceptability of online educational strategies for high school learners

Template (Wordpress Site)

- Title:
  Prepared by:
  Possible Lecturer/s:
  Contact hours: For consistency reasons, each contact hour is fixed at 45min.
  Theory (XXhrs), Practicals (XXhrs)
- Aim
- Content Description
- Prerequisites
- Competencies & level of competencies aimed at
- Learning Outcomes
- Description of Case Study/ies
- Indicative Content & Activities/Practicals
- Assessments & Weights
- Additional Readings
- References
- Resources required
- Support required

Core competencies

- Some work done in this area already:

Framework for development of physician competencies in genomic medicine: report of the Competencies Working Group of the Inter-Society Coordinating Committee for Physician Education in Genomics

Bruce R. Korf, MD, PhD[1], Anna B. Berry, MD[2,3], Melvin Limson, PhD[4], Ali J. Marian, MD[5], Michael F. Murray, MD[6], P. Pearl O'Rourke, MD[7], Eugene R. Passamani, MD[8], Mary V. Relling, PharmD[9], John Tooker, MD, MBA[10], Gregory J. Tsongalis, PhD[11,12] and Laura L. Rodriguez, PhD[8]

- Expanding on or adapting these where necessary for African setting

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Competencies: EPAs (Entrustable Professional Activities)

- **A. Family History:** elicit, document, and act on relevant family history pertinent to the patient's clinical status;
- **B. Genomic Testing**: use genomic testing to guide patient management;
- **C. Treatment Based on Genomic Results:** use genomic information to make treatment decisions;
- **D. Somatic Genomics:** use genomic information to guide the diagnosis and management of cancer and other disorders involving somatic genetic changes; and
- **E. Microbial Genomic Information**: use genomic tests that identify microbial contributors to human health and disease, as well as genomic tests that guide therapeutics in infectious diseases.
- **F. Research:** engage with communities in an ethical and culturally acceptable manner

NHS competencies

	Role	Clinical bioinformatician	Other bioinformatician	Specialist clinician with genetics/genomics expertise	Other specialist clinician	Other clinician	Clinical genetic Scientist
	No. responses	11	6	5	5	6	8
	Example	NHS diagnostic bioinformatician [1]	Academic bioinformatician, industry bioinformatician	Clinical geneticist or pathologist, haematologist, microbiologist with leadership responsibility in clinical lab	Cardiologist, neurologist, oncologist, paediatrician	General Practitioner	NHS diagnostic clinical scientist, microbiologist, statistical/analytical epidemiologistt
Competency	Write computer programmes and algorithms that can analyse data	Specialist knowledge	Specialist knowledge	No knowledge required	No knowledge required	No knowledge required	Awareness
	Analyse genomics data using pre-existing software, including linking genotype to phenotype/microbial strain comparisons	Specialist knowledge	Specialist knowledge	Specialist knowledge[2]	Awareness	No knowledge required	Specialist knowledge
	Employ good software development practice	Working knowledge	Specialist knowledge	No knowledge required	No knowledge required	No knowledge required	No knowledge required
	Apply computer science theory to computer system design	Working knowledge	Working knowledge	No knowledge required	No knowledge required	No knowledge required	No knowledge required
	Manage and organise genomics data and results	Specialist knowledge	Specialist knowledge	Awareness[2]	No knowledge required	No knowledge required	Working knowledge
	Apply statistical research methods to genomics, medical, and population genetics	Working knowledge	Specialist knowledge	Working knowledge	No knowledge required	No knowledge required	Awareness[4]
	Use health informatics systems and understand their relevance to clinical genomics	Working knowledge	Awareness	Specialist knowledge	Awareness	Awareness	Awareness
	Principles of genetics, genomics and genome-sequencing technology	Specialist knowledge	Specialist knowledge	Specialist knowledge	Awareness	Awareness	Specialist knowledge
	Principles of genetic disease	Working knowledge	Working knowledge	Specialist knowledge	Working knowledge	Working knowledge	Specialist knowledge
	Principles of systems biology	Working knowledge	Working knowledge	Awareness	No knowledge required	Awareness	Awareness
	Principles of next generation sequencing	Specialist knowledge	Specialist knowledge	Awareness	Awareness	Awareness	Specialist knowledge
	Ethical, legal and social implications of clinical use of genomic data (including issues surrounding identification of patients, clinical benefits and risks, patient consent, incidental findings and ethical implications of unexpected clinically actionable findings	Working knowledge	Working knowledge	Specialist knowledge	Working knowledge	Working knowledge	Specialist knowledge

Summary & conclusions

- All learning a lot about educational practice!
- Experimenting with different learning strategies
- Targeting a wide range of audiences
- Very important to focus on who we want to teach and what we need them to know and be able to do after training