Digital*DNA*: Re-thinking traditional BI development techniques for evidence-based decision making

Glen Barnes & Liz Archer

18 October 2016

introduction

- In this article an alternate approach is explored where the focus is on establishing a comprehensive, highly navigable Decision Network Application known as Digital*DNA*, which allows users to navigate and interrogate data in '**appropriate time**' to address their dynamic informational needs.
- The focus is on designing and integrating enriched data sets with an intuitive navigation system allowing users to easily move between various data nodes and explore each node in detail to gain a comprehensive understanding of the '**appropriate time**' data relating to their specific challenge.

evidence-based decision making …

need to access – navigate – disseminate : quickly, accurately …
traditional drill-down, drill-through, user-needs analysis : limited …

objectives

- move towards enhancing the ability to disseminate, navigate, visualise and 'interpret' complex, integrated and enriched data sets for evidence-based decision making
- design and deploy tools that 'connect' data points in a way the minimises the 'distance' between points and offers a broader and more comprehensive view of data and information
- develop a system of data dissemination and navigation that is 'intelligent', scalable and agile

presentation

- theoretical framework
  - Complex Adaptive Systems (CAS)
- methodology
  - Design Research
  - two distinct outcomes:
  1. an intervention or product to address the issue being studied, and
  2. a set of design principles to implement the intervention in other contexts.

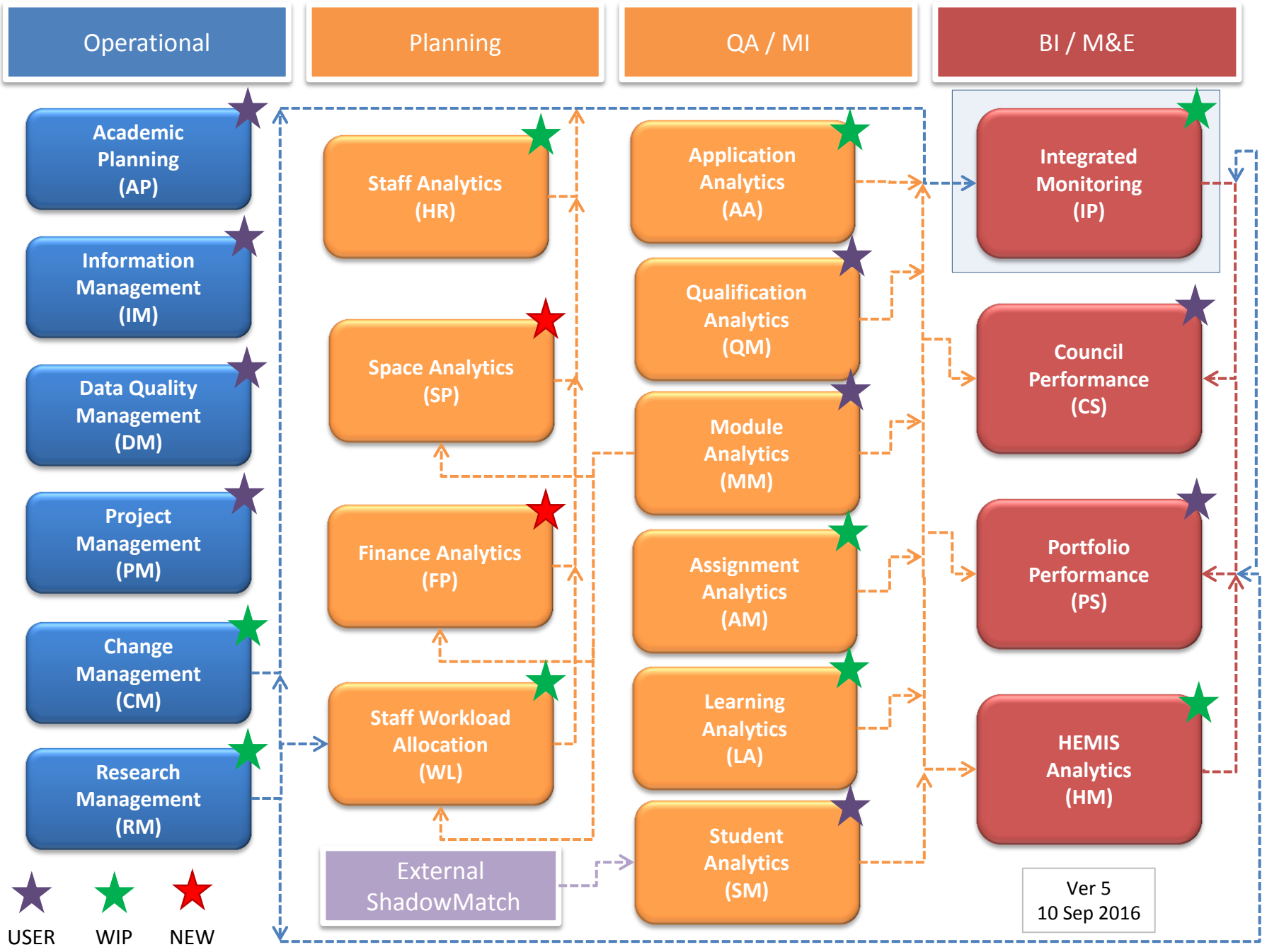
design principles …

emergent characteristics of Complex Adaptive System (CAS) principles

Principle	Explanation
Emergence	What appears as random interactions between agents in the system are patterns which informs the actions of the agents and system itself.
Co-evolution	Systems exist within environments, to ensure fit they must change with the environment which in turn adapts to the system.
Sub-optimal	The system should be good enough, not perfect, as the goal is efficiency within constant change.
Requisite Variety	Ambiguity, paradox and contradictions to create new possibilities, so variety is essential for ingenuity and creativity.
Connectivity	Relationships between agents are critical to the systems survival, these represent the patterns which ensure the survival of the system.
Simple Rules	The rules governing system functioning are simple even if the patterns are varied and rich.
Iteration	Small changes can have significant impact through the emergence of feedback loops.
Self-organising	No hierarchy, command or control, just constant organising to find the best fit.
Edge of Chaos	The systems exist on a spectrum ranging from equilibrium to chaos, with the edge of chaos representing the most variety and creativity. Rules and restrictions ensure some predictability.
Nested Systems	Systems are nested in other systems with systems often being smaller sub-systems within larger systems.

(see Choi et al., 2001; Dooley, 1997; Dougherty et al., 2016; Lewin & Regine, 1999; McGreevy, 2008)

the product …


Operational
Planning
QA / MI
BI / M&E
Academic Planning (AP)
Information Management (IM)
Data Quality Management (DM)
Project Management (PM)
Change Management (CM)
Research Management (RM)
Staff Analytics (HR)
Space Analytics (SP)
Finance Analytics (FP)
Staff Workload Allocation (WL)
External ShadowMatch
Application Analytics (AA)
Qualification Analytics (QM)
Module Analytics (MM)
Assignment Analytics (AM)
Learning Analytics (LA)
Student Analytics (SM)
Integrated Monitoring (IP)
Council Performance (CS)
Portfolio Performance (PS)
HEMIS Analytics (HM)
USER
WIP
NEW
Ver 5
10 Sep 2016

data points connected by both data and system connections …

Actual Module Profiles

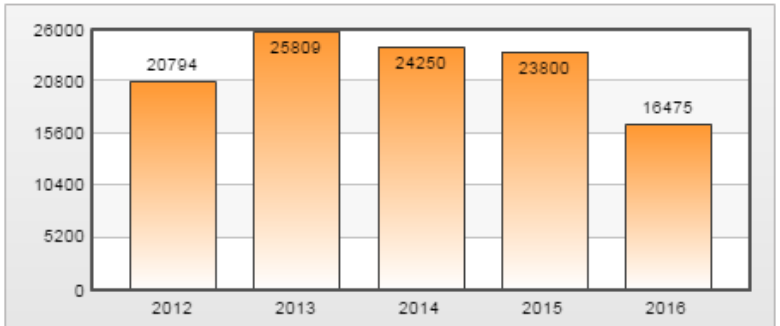
2017

Demographic Group

2016 Cohort by ' Demographic Group '

Demographic Group	ENR	(%)
African Female	16 475	47,3%
African Male	7 575	21,8%
Coloured Female	619	1,8%
Coloured Male	358	1,0%
Indian Female	1 498	4,3%
Indian Male	486	1,4%
Unknown Female	156	0,4%
Unknown Male	70	0,2%
White Female	4 993	14,3%
White Male	2 569	7,4%
TOTAL	34 799	

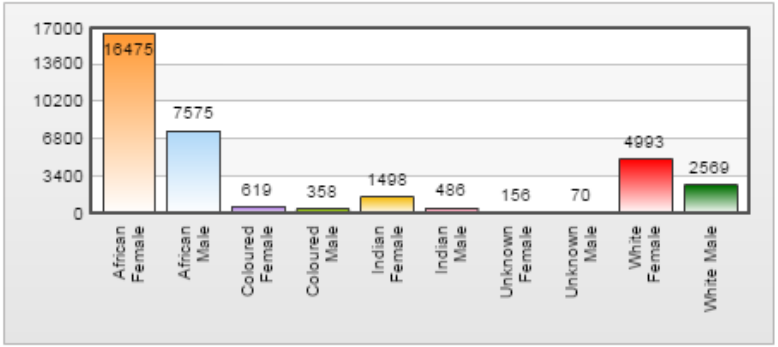
Cohort Enrolments for Demographic Group = ' African Female ' (Cnt)



	2012	2013	2014	2015	2016
Cnt	20 794	25 809	24 250	23 800	16 475
Tot	47 958	55 869	51 606	49 863	34 799
(%)	43,4%	46,2%	47,0%	47,7%	47,3%

(CollegeCode=5) (Module_Formal='Formal') (Status_Code IN('RG', 'NC'))

2016 Cohort by ' Demographic Group ' as Counts



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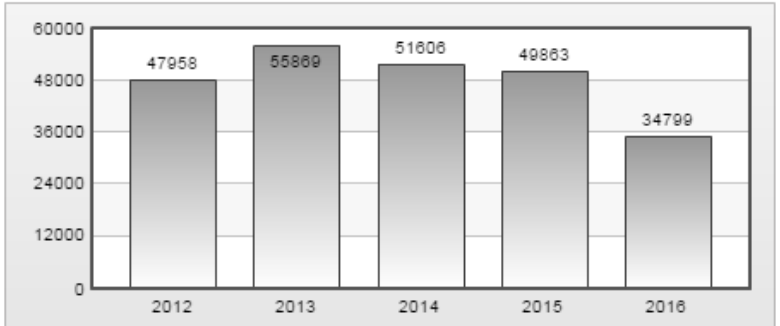

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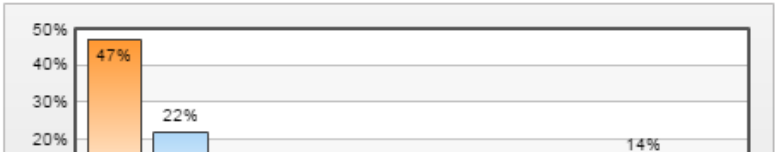

navigate : app foyer -> module app -> profile dashboard -> college -> demographic group

UNISA university of south africa

User: barnegr (1)
Level: 4
DBase: 2
15 October, 2016

Actual Module Profiles

Org Structure

- UNISA ...
  - + COLLEGE OF ACCOUNTING SCIENCES
  - − COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES
    - + SCHOOL OF AGRICULTURE AND LIFE SCIENCES
    - − SCHOOL OF ENVIRONMENTAL SCIENCES
      - + DEPT OF GEOGRAPHY
      - − DEPT ENVIRONMENTAL SCIENCES
        - + NQF 5
        - + NQF 6
        - − NQF 7
          - BRM4701 - Biological research methodology
          - BTN001P - FIRST PRACTICAL CONTACT COURSE (NATURE CONSERVATION)
          - BTN002P - SECOND PRACTICAL CONTACT COURSE (NATURE CONSERVATION)
          - BTN003P - THIRD PRACTICAL CONTACT COURSE
          - COC4701 - Contact Session I
          - COC4702 - Contact Session II

2016

Demogra		
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African Male		
Coloured Female		
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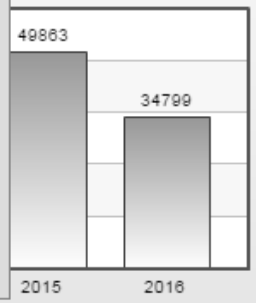

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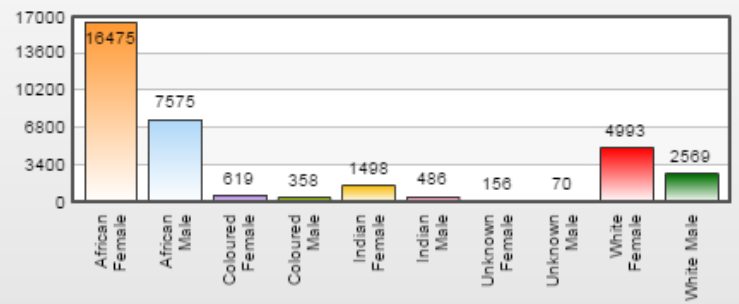
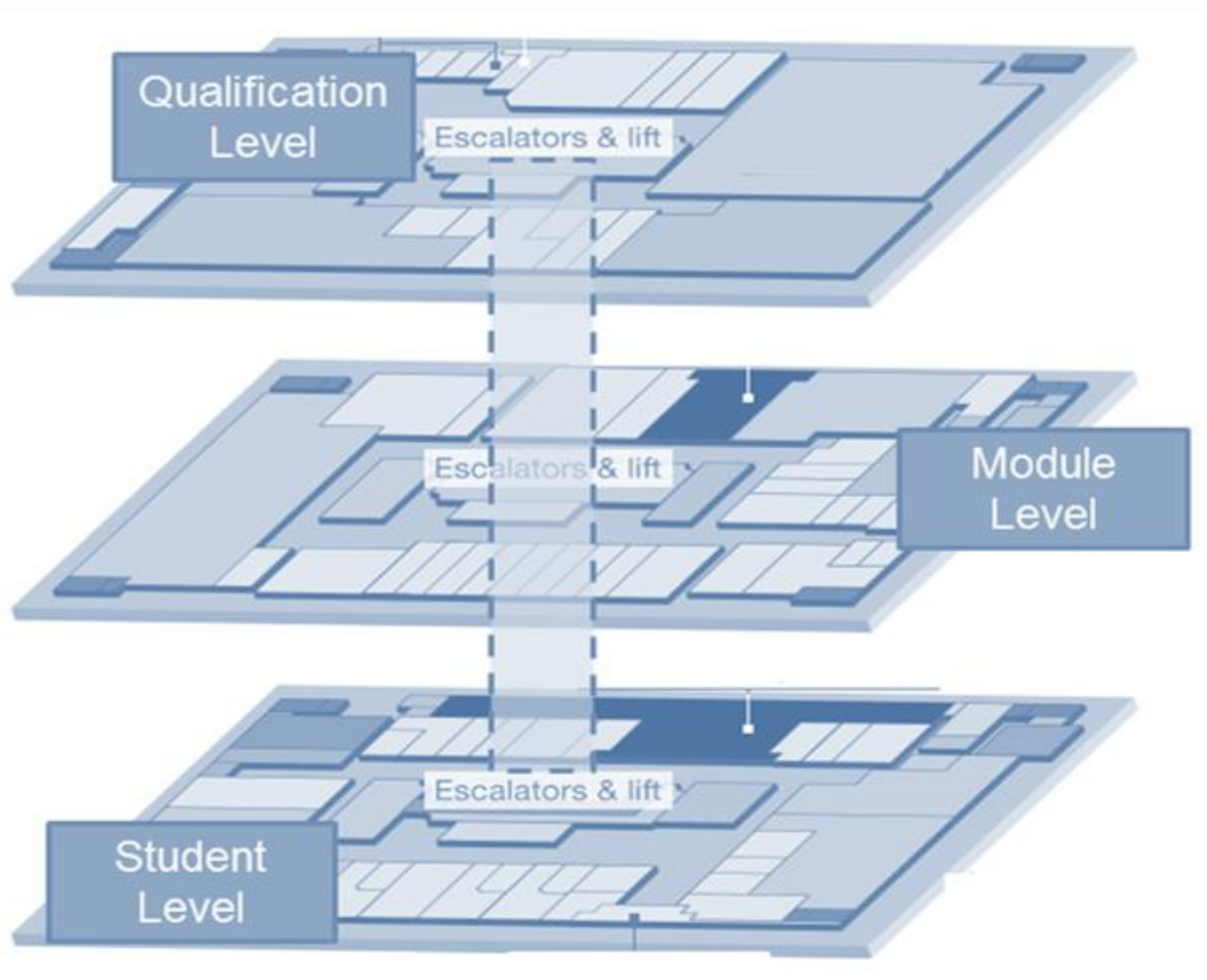


2016 Cohort by ' Demographic Group ' as % of Total

typical drill-down and drill-through BI development …



observations …

- navigation determined and confined by the **‘modular’** construct of integrated systems and components

- hierarchies are very structured, **data driven**, cumbersome, slow, inefficient

solution …

- integrate both **data** and **system** components into the navigation
- define **and link** various points of entry in the ‘data sphere’
- plug-in design makes an ‘intelligent’ system that is **responsive** and comprehensive

simplest example …

Demographic Group

2016 Cohort by ' Demographic Group '

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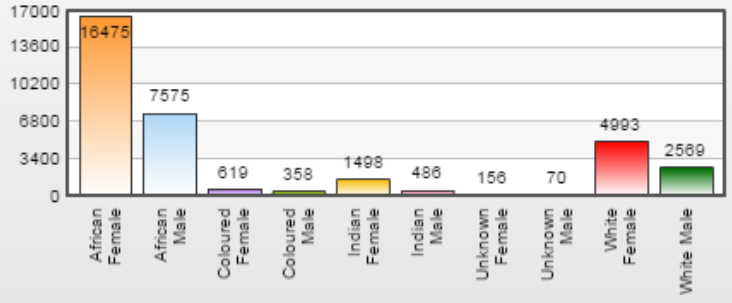

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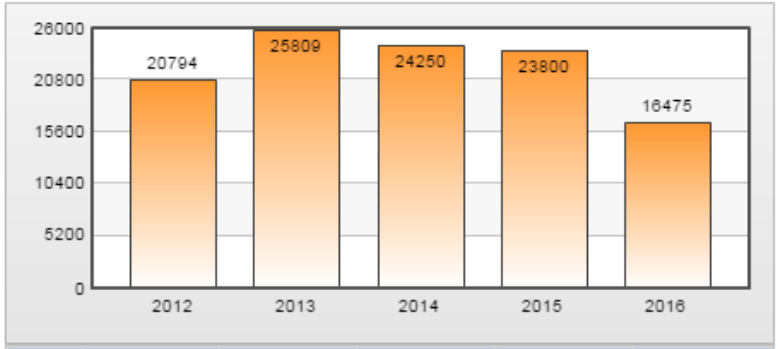

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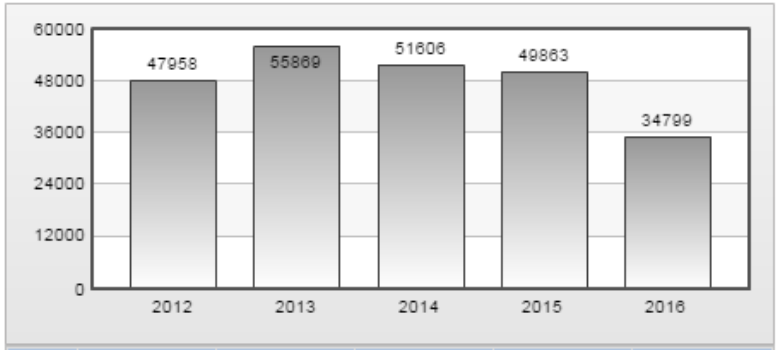

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College 5 - Digital DNA Links [4]

DIA-SM Student
- Biographical profile
- Habits & behavior profile

DIA-MM Module
- Summary dashboard
- Actual enrolment profiles
- Modules 'At Risk' report

DIA-QM Qualification
- Actual enrolment profiles
- Actual graduate profiles

DIA-PS Portfolio Performance
- College progress
- College scorecard

DIA-IP Integrated Portal
- College dashboard

yer=&txt=&sem=&sta=RG, NC&srt=Cat&dim=2d&rpl=&for=Formal&ale=&dte=&sum=ENR&asc=DESC&tpp=50&fld=Demographic_Group&hub=

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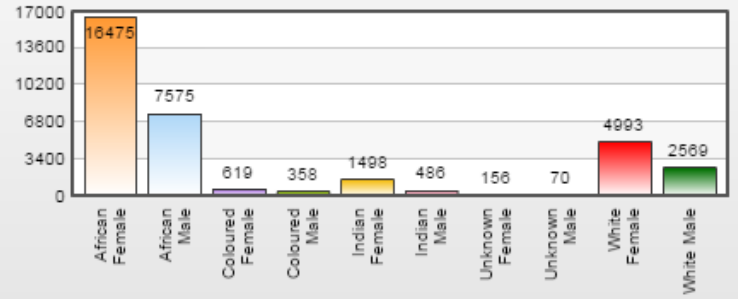

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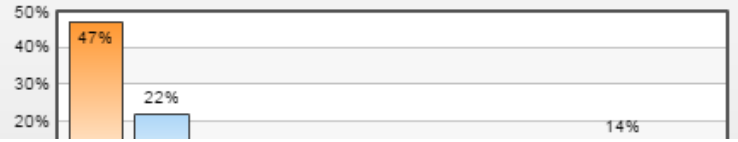

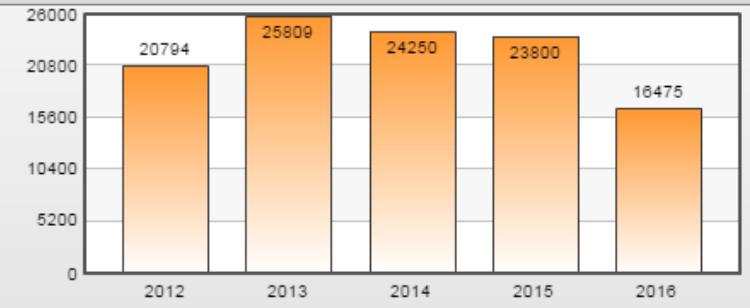

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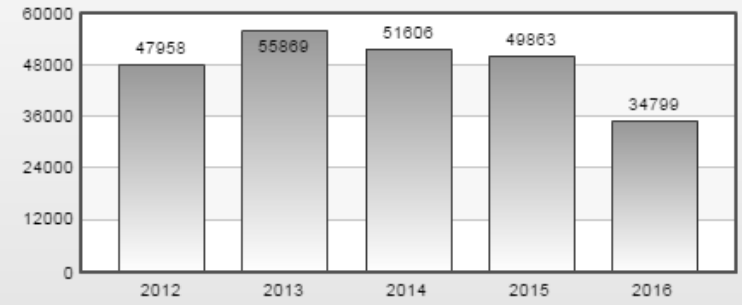

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more detailed example …

UNISA university of south africa

Module Analytics App (DIA-MM ver 5.4A - rel 24.03.2016)

User: barnegr (1)
Level: 4
DBase: 2
15 October, 2016

Module Quality Assurance

UNISA | CAES | CAS | CEDU | CEMS | CGS | CHS | CLAW | CSET | ICB | OCC | OTHER

Col	Code	Module Description	Academic level	NQF HEQF	Active From Year To Year	Data Min Year Max Year	Formal Active	SME for 2016	PDF for 2016	Report
CAES	AEA271V	AGRICULTURAL ECONOMICS - (Replaced by: AME1501)	UnderGraduate	6 6	1992 2019	2005 2017	For Y			

Module: AEA271V Year: 2016 New: AME1501

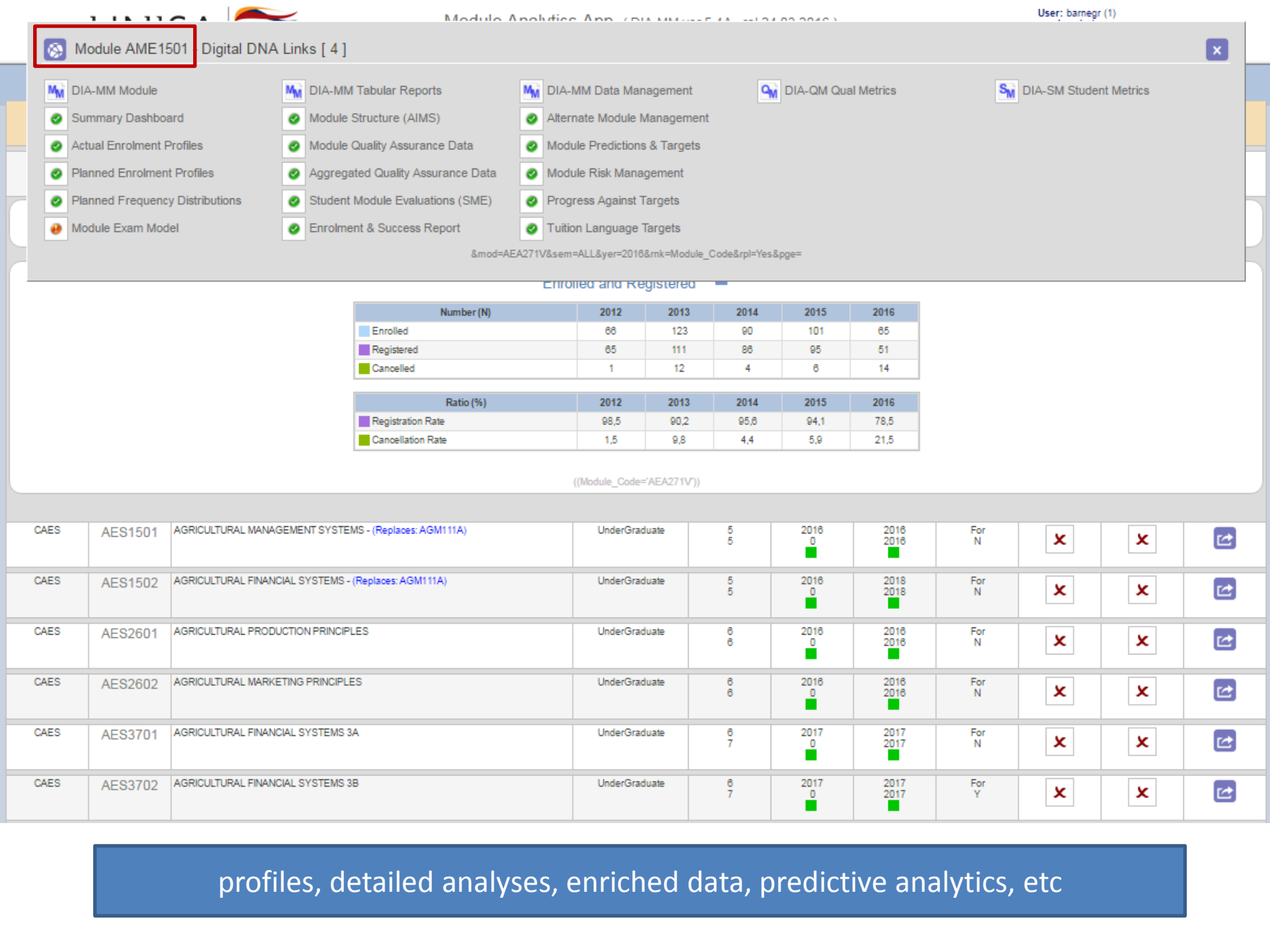
Enrolled and Registered

Number (N)	2012	2013	2014	2015	2016
Enrolled	66	123	90	101	65
Registered	65	111	86	95	51
Cancelled	1	12	4	6	14

Ratio (%)	2012	2013	2014	2015	2016
Registration Rate	98,5	90,2	95,6	94,1	78,5
Cancellation Rate	1,5	9,8	4,4	5,9	21,5

((Module_Code='AEA271V'))

CAES	AES1501	AGRICULTURAL MANAGEMENT SYSTEMS - (Replaces: AGM111A)	UnderGraduate	5 5	2016 0	2016 2016	For N			
CAES	AES1502	AGRICULTURAL FINANCIAL SYSTEMS - (Replaces: AGM111A)	UnderGraduate	5 5	2016 0	2018 2018	For N			
CAES	AES2601	AGRICULTURAL PRODUCTION PRINCIPLES	UnderGraduate	6 6	2016 0	2016 2016	For N			
CAES	AES2602	AGRICULTURAL MARKETING PRINCIPLES	UnderGraduate	6 6	2016 0	2016 2016	For N			
CAES	AES3701	AGRICULTURAL FINANCIAL SYSTEMS 3A	UnderGraduate	6 7	2017 0	2017 2017	For N			
CAES	AES3702	AGRICULTURAL FINANCIAL SYSTEMS 3B	UnderGraduate	6 7	2017 0	2017 2017	For Y			



profiles, detailed analyses, enriched data, predictive analytics, etc

more detailed example …

UNISA university of south africa

Student Analytics App (DIA-SM ver 2.3A - rel 01.05.2016)

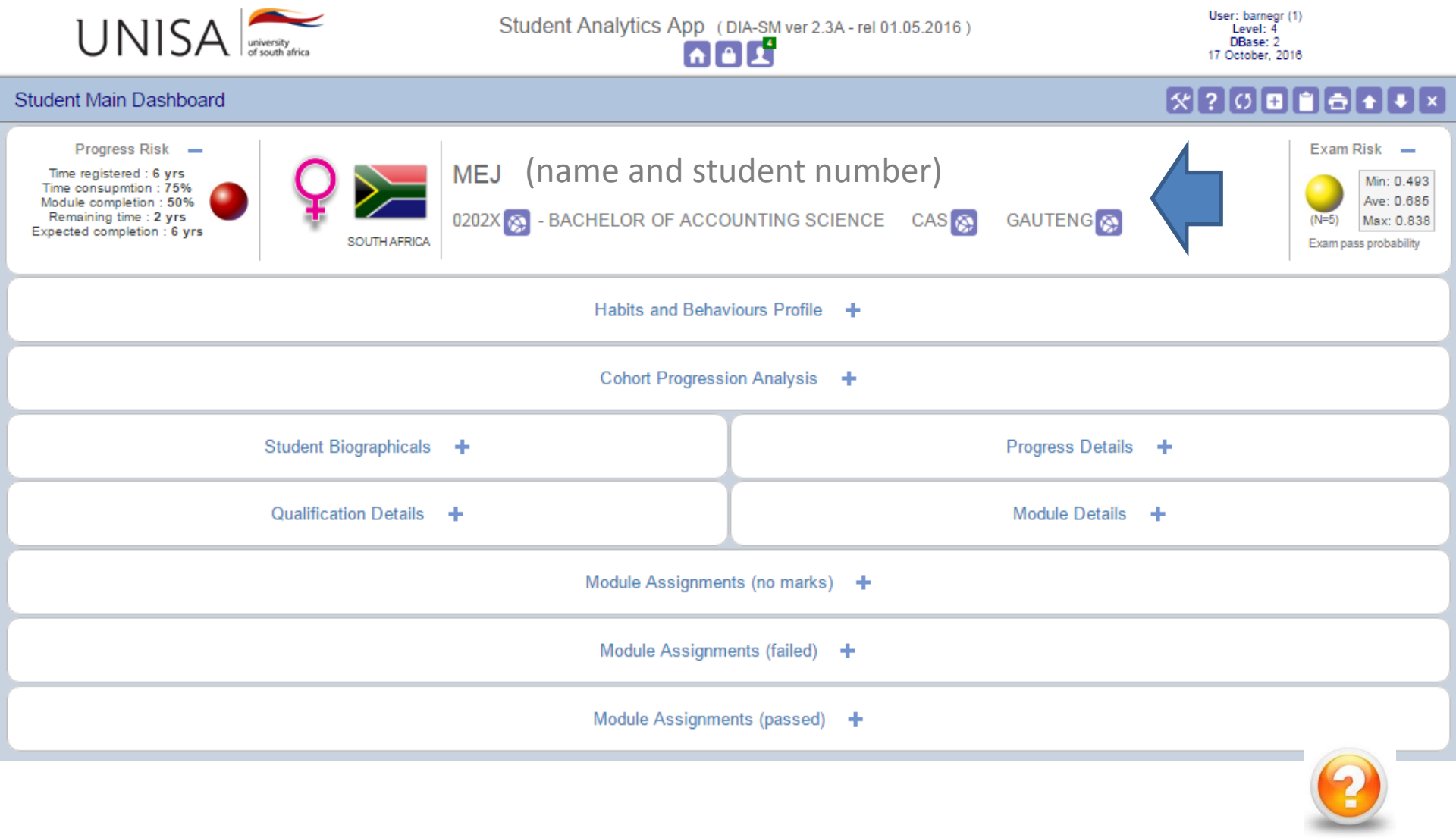
User: barnegr (1)
Level: 4
DBase: 2
17 October, 2016

Progression Risk Student List

UNISA | CAES | CAS | CEDU | CEMS | CGS | CHS | CLAW | CSET | ICB | OCC | OTHER

Qual Code Qualification	Formal Framework	Min Time Max Time	Student Number Student Name & (Country)	Race Gender	Home Language	First Year FTEN	MyUnisa Flag	Assign. Activity	Final Year Flag	Completed Flag	H & B Profile	Years Registered	Modules Registered Passed (N)	Pass Rate	Work Load	Progress Rate
							Page 1 of 115									
0202X BCOMPT	Formal (NQF)	Min 3 yrs Max 8 yrs	46518517 (SOUTH AFRICA)	African Female	NORTHERN SOTHO	2011 N	✓	✓	✗	✗		6	35 29	82.9	5.8	4.8
0202X BCOMPT	Formal (NQF)	Min 3 yrs Max 8 yrs	48340375 (SOUTH AFRICA)	White Male	AFRIKAANS	2011 N	✓	✓	✗	✗		6	29 21	72.4	4.8	3.5
0202X BCOMPT	Formal (NQF)	Min 3 yrs Max 8 yrs	48436852 (SOUTH AFRICA)	White Male	AFRIKAANS	2011 N	✓	✓	✗	✗		6	14 3	21.4	2.3	0.5
0202X BCOMPT	Formal (NQF)	Min 3 yrs Max 8 yrs	49617028 (SOUTH AFRICA)	African Male	ISIZULU	2011 N	✓	✓	✗	✗		6	28 18	64.3	4.7	3
0202X BCOMPT	Formal (NQF)	Min 3 yrs Max 8 yrs	46450076 (ZIMBABWE)	African Female	ENGLISH	2011 N	✓	✓	✗	✗		6	35 28	80	5.8	4.7
0202X BCOMPT	Formal (NQF)	Min 3 yrs Max 8 yrs	49261843 (SOUTH AFRICA)	White Female	AFRIKAANS	2011 N	✓	✓	✗	✗	✓	6	24 15	62.5	4	2.5
98332 BCOMPT FFAC	Formal (HEQF)	Min 3 yrs Max 8 yrs	48084808 (SOUTH AFRICA)	White Female	AFRIKAANS	2011 N	✓	✓	✗	✗		6	24 19	79.2	4	3.2
98332 BCOMPT FFAC	Formal (HEQF)	Min 3 yrs Max 8 yrs	48121673 (ZIMBABWE)	African Female	SHONA	2011 N	✓	✓	✗	✗		6	27 19	70.4	4.5	3.2
98332 BCOMPT FFAC	Formal (HEQF)	Min 3 yrs Max 8 yrs	46594345 (ZIMBABWE)	African Female	SHONA	2011 N	✓	✓	✓	✗		6	29 25	86.2	4.8	4.2
98332 BCOMPT FFAC	Formal (HEQF)	Min 3 yrs Max 8 yrs	49136615 (SOUTH AFRICA)	White Male	ENGLISH	2011 N	✓	✓	✗	✗		6	25 21	84	4.2	3.5

one of the many ways of drilling down to the student …



convergence of student, qual, module, enriched data & analytics – on demand

UNISA university of south africa

Student Analytics App (DIA-SM ver 2.3A - rel 01.05.2016)

User: barnegr (1)
Level: 4
DBase: 2
17 October, 2016

Student Main Dashboard

Progress Risk

Time registered : **6 yrs**
Time consupmtion : **75%**
Module completion : **50%**
Remaining time : **2 yrs**
Expected completion : **6 yrs**

SOUTH AFRICA

MEJ (name and student number)

0202X - BACHELOR OF ACCOUNTING SCIENCE CAS GAUTENG

Exam Risk

(N=5)
Min: 0.493
Ave: 0.685
Max: 0.838
Exam pass probability

Habits and Behaviours Profile +

Cohort Progression Analysis +

Student Biographicals +

Progress Details +

Qualification Details +

Module Details +

Module Assignments (no marks)

College	First Year	Last Year	Academic Period	Module Code	Module Name	NQF Level	Study Level	Assignment Activity	Assignments Submitted	Attempts	Low Mark	High Mark	Pass
CAS	2016	2016	Semester 1	FAC3702	DISTINCT FINANCIAL REPORTING	6	3	Y	2	1	0	0	-
CAS	2013	2013	Semester 1	AUE2602	CORP GOVERN IN ACCOUNTANCY	6	2	Y	2	1	0	0	-
CAS	2013	2013	Semester 2	AIN1501	ACCOUNTING INFORMATION SYSTE	5	1	Y	3	1	0	0	-
CAS	2013	2013	Semester 2	FAC2601	FIN ACC FOR COMPANIES	6	2	Y	2	1	0	0	-

Codes: FAC3702, AUE2602, AIN1501, FAC2601

UNISA university of south africa

Student Analytics App (DIA-SM ver 2.3A - rel 01.05.2016)

User: barnegr (1)
Level: 4
DBase: 2
17 October, 2016

Student Main Dashboard

Module FAC3702 - Digital DNA Links [4]

- DIA-MM Module
- Summary Dashboard
- Actual Enrolment Profiles
- Planned Enrolment Profiles
- Planned Frequency Distributions
- Module Exam Model
- DIA-MM Tabular Reports
- Module Structure (AIMS)
- Module Quality Assurance Data
- Aggregated Quality Assurance Data
- Student Module Evaluations (SME)
- Enrolment & Success Report
- DIA-MM Data Management
- Alternate Module Management
- Module Predictions & Targets
- Module Risk Management
- Progress Against Targets
- Tuition Language Targets
- DIA-QM Qual Metrics
- DIA-SM Student Metrics

&

Student Biographicals +

Progress Details +

Qualification Details +

Module Details +

Module Assignments (no marks) −

College	First Year	Last Year	Academic Period	Module Code	Module Name	NQF Level	Study Level	Assignment Activity	Assignments Submitted	Attempts	Low Mark	High Mark	Pass
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CAS	2013	2013	Semester 2	AIN1501	ACCOUNTING INFORMATION SYSTE	5	1	Y	3	1	0	0	-
CAS	2013	2013	Semester 2	FAC2601	FIN ACC FOR COMPANIES	6	2	Y	2	1	0	0	-

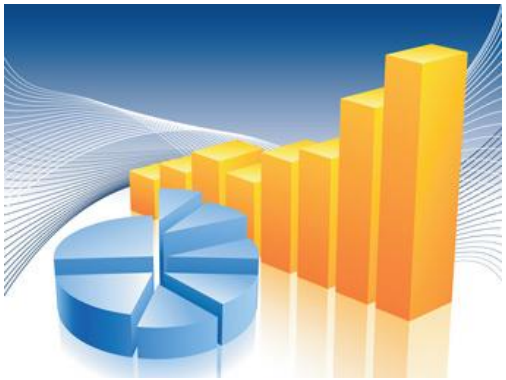
Codes: FAC3702, AUE2602, AIN1501, FAC2601

characteristics of Complex Adaptive System principles applied to the DigitalDNA system

Principle	Explanation	Operationalisation in DigitalDNA
Emergence	What appears as random interactions between agents in the system are patterns which informs the actions of the agents and system itself.	Data points and sets are linked via common attributes that may not necessarily be structural or hierarchical.
Co-evolution	Systems exist within environments, to ensure fit they must change with the environment which in turn adapts to the system.	Information is integrated with existing sets on the basis of 'related data' within the 'student walk' process and beyond.
Sub-optimal	The system should be good enough, not perfect, as the goal is efficiency within constant change.	Since the first draft of this article through the review process the system has evolved and several new functionalities developed.
Requisite Variety	Ambiguity, paradox and contradictions to create new possibilities, so variety is essential for ingenuity and creativity.	Variety is constrained only by the underlying availability of data recorded for each process and the questions posed.
Connectivity	Relationships between agents are critical to the systems survival, these represent the patterns which ensure the survival of the system.	Connectivity is the key driver of the system, 'connectedness' is determined largely by the user and not by organisational structure.
Simple Rules	The rules governing system functioning are simple even if the patterns are varied and rich.	Navigation 'rules' follow the known and possible decisions around the 'student walk' and monitoring.
Iteration	Small changes can have significant impact through the emergence of feedback loops.	An attempt on facilitating feedback loops is contained in the navigation design and is currently focus of further attention.
Self-organising	No hierarchy, command or control, just constant organising to find the best fit.	(see the points on Emergence and Co-evolution above)
Edge of Chaos	The systems exist on a spectrum ranging from equilibrium to chaos, with the edge of chaos representing the most variety and creativity. Rules and restrictions ensure some predictability.	The system currently runs the risk of 'information overload' to the user, further developments in this regard will consider mapping a suite of 'decision pathways' to address this issue.
Nested Systems	Systems are nested in other systems with systems often being smaller sub-systems within larger systems.	This is facilitated through the integration of various data elements but connected via relationships and not structures.

conclusions

- The DigitalDNA development is more comparable with DSS development than with typical learner analytics visualisations and can be classified as born out of (but gone beyond) the **data-driven DSS toolsets** described by Kacprzyk and Zadrozny (2007).
- The primary design concern is the linkage of a number of centrally enriched data sets which means that **exploration logic** now becomes the focus as opposed to the needs of a particular user or the capabilities and interface of any particular dashboard development software.
- The focus (at this stage) is not on data visualisation and memorability, but rather on 'real-time' navigable data with **various display options** for users to choose from. In addition, effort is given to link multiple data points in a way that is logical to the user in areas they are not familiar with.
- The user may thus identify and explore areas of interest of data surrounding **key nodes**, with the ability to extensively connect to **related areas**. The shift is thus from canned (pre-packaged) reporting to the flexibility of data exploration (on demand) in 'appropriate time'.



Thank you …