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EDUCATION POLICY | RESEARCH ARTICLE

Key drivers of graduate students' interest in the subject of immunology in a tertiary institution of Ghana

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Abstract: Immunology is increasingly becoming a core biomedical discipline in recent times. Students' interest in Science, Technology, Engineering and Mathematics programs is essential for better academic performances and outcomes in a University of Science Technology. To this end, we assessed the factors that influence students' interest in immunology among a group of 32 graduate students in a tertiary institution in Ghana. The study was conducted using quantitative instruments (questionnaires) after which principal component analysis (PCA) was used to reveal the underlying factors affecting students' interest in the course. In all, six components were found including students' perception, instructor quality, student's interest/motivation, teaching methods, teaching materials and teaching facilities. Students' interest in immunology correlated negatively but significantly with perception; however, interest correlated positively with teaching methods ($p < 0.001$). Our study is the first to investigate the factors that influence students'

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Alexander Kwarteng, PhD, in Molecular Biomedicine is a faculty at the Department of Biochemistry and Biotechnology, Kwame Nkrumah University of Science and Technology, Kumasi-Ghana. Dr Kwarteng is passionate about immunology education and training in developing countries and has in the past been involved in the development of courses and instructional materials centred on this theme. He posits that effective training of immunologists will demand huge capital and resource investment given the high cost of establishing and maintaining immunology core facilities, to run experiments, demonstrations and practical sessions. He believes that developing countries have other urgent sectors to support with limited resources, however, given the benefits of immunology education and research, these nations should reconsider dedicating adequate financial support and national commitment to the area of immunology education and research to quickly bridge the huge deficit of immunologists in developing countries.

PUBLIC INTEREST STATEMENT

Immunology is one of the most important life science disciplines. There is a growing interest in the study of immunology among graduate students in developing countries. Students' interest in any discipline affects students' academic performance and competence. The interest for immunology as a discipline among the study participants was found to be driven by six main factors (principal components) such as students' perception, instructor quality, student's interest/motivation, teaching methods, teaching materials and teaching facilities. Given the significant health benefits of immunology education and research, particularly in developing countries with massive health needs, we determined whether there is any association between interest in immunology and any of the six components identified. We observed a significant positive relationship between graduate students' interest in immunology and teaching materials. Findings from this study suggest that in order to grow the interest of students in a life science discipline such as immunology, there will be the need to invest significantly in as teaching materials and facilities.

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interest in immunology in Ghana and supports the growing functionality of PCA approach for dimension reduction and exploratory factor analysis.

Subjects: Immunology; Medicine; Immunology

Keywords: Immunology; principal component analysis; interest; Ghana

1. Introduction

The significant human health and socioeconomic impact of infectious and chronic diseases in developing countries have inspired the development of innovative and high-throughput technologies for diagnosis, prognosis and following treatment regimens (Acharya, Kennedy, Daar, & Singer, 2004, Nuhs et al., 2015). In the same way, disciplines such as immunology and molecular biology of infectious diseases have emerged, all in an attempt to further understand the interaction between pathogens and hosts. Immunology and molecular biology are driving research into discovery and development of vaccines to fight some of the deadliest diseases such as HIV, malaria, cancer and TB. Immunology research and development in the global south has been met with challenges such as lack of research funding, limited expertise and equipment as well as a little emphasis on the study of immunology in biomedical training programs both at undergraduate and graduate levels (Gotch & Gilmour, 2007; Harris, 2004; Karikari, 2015).

While there seems to be a lot of challenges in integrating immunology as a discipline in most curricula in developing countries, identifying the factors that drive students interest is key. However, given that several factors could contribute to graduate students' interest in immunology, applying a comprehensive statistical approach to identifying these factors is essential. Interestingly, handling large datasets are increasingly common and are often difficult to interpret given the numerous variables one would have to deal with (Badaoui, Amar, Ait Hassou, Zoglat, & Okou, 2017). Hence, one of the primary approaches which has stood the test of time in going around such a challenge is principal component analysis (PCA) (Joliffe & Morgan, 1992).

Analysing data on the factors that influence graduate interest in immunology is crucial to the choice of students in this life science program. The presence of large inter-individual differences in assessing students' interest in immunology further clouds the interpretation of obtained data. Therefore, developing novel approaches to evaluate the interrelationship among the several factors that influence interest in immunology is critical in attempting to improve our understanding of the students' choice of immunology as a graduate program. In view of this, we used PCA to analyse complex multidimensional datasets and hypothesis-generating patterns of interest (Aitchison, 1983). PCA transforms large sets of potentially inter-related variables into a smaller and ideally more manageable dataset of composite variables thereby making it well suited to perform exploratory analyses of complex data (Ma & Dai, 2011). Moreover, we selected this approach with the goal of identifying potentially significant factors, which drive graduate students' interest in immunology as a discipline.

2. Materials and methods
3. Study setting

The study was carried out at the Kumasi Centre for Collaborative Research in tropical medicine (KCCR), Ghana. KCCR is one of Africa's leading biomedical research institutions that was established from a collaboration between Kwame Nkrumah University of Science and Technology, College of Health Sciences (CHS), Ghana; Ministry of Health; and the Bernhard-Nocht Institute for Tropical Medicine (BNITM), Hamburg, Germany. The centre has been a centre of excellence in tropical medicine and has played a significant in training scientists to tackle some of the greatest health needs of Ghana.

4. Sample population and sampling techniques

Study participants included undergraduate life science students from the Kwame Nkrumah University of Science and Technology (KNUST) who took part in a one-week workshop on the

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‘Introduction to Immunology’. The workshop was organised at the Kumasi Centre for Collaborative Research in Tropical Medicine (KCCR) as part of a larger study which was investigating the pattern of immune response of children with *Mycobacterium tuberculosis* in Ghana. The main inclusion criterion for this study was participation in the ‘Introduction of Immunology’ workshop and willingness to give signed informed consent. Having agreed to participate in the study, participants were given questionnaire to be completed independently.

5. Data collection tools/instruments

A quantitative approach (questionnaire) was used to determine the level and the underlying factors for graduate students’ interest in immunology. A detailed description of the survey instruments was reported in a previous study (Walker, Ziegler, & Becher, 2016). Questionnaires for this study were self-constructed based on students’ areas of difficulty over several years of teaching immunology course. In addition, the socio-demographic section of the questionnaire was used to capture basic information such as gender, age and course of study, graduating class among others of the study participants. A five-point Likert-scale was used to determine students’ preference for mode of delivery by lecturers in immunology. However, to assess the reliability of our survey instruments and constructs (such as the mode of delivery by lecturers in immunology) Cronbach’s alpha coefficient was estimated at 0.867. Therefore, the high level of reliability coefficient in this study suggests that the instruments used to investigate graduate students’ preferred mode of delivery by lecturers are reliable which supported further analysis. The structured questionnaires were administered to all participants at the end of the workshop for participants’ response followed by data analysis.

6. Ethical approval

The study was part of an immune profile study among individuals with *Mycobacterium tuberculosis* infection in Ghana approved by the Committee on Human Research, Publication and Ethics (CHRPE) of the School of Medical Sciences of the Kwame Nkrumah University of Science and Technology, Ghana (Approval Number: CHRPE/AP/179/16). Study procedures were in accordance with the Helsinki Declaration of 2000.

7. Statistical analysis

Data cleaning, validations and analysis were performed using SPSS version 19.0. Descriptive statistics were carried out on the dataset in addition to exploratory factor analysis to determine the underlying factors contributing to graduate students’ interest in immunology. The study determined the number of components to be extracted from the measures of graduate students’ interest in immunology. The Kaiser’s criterion only seeks component with eigenvalues of 1 or more (Table 1) and after the final rotated component matrix, six components were kept and the result of the rotated factor analysis is shown in (Table 3). These six components explain a total of 81.97% of the variance (Table 2). The result shows that measures of graduate students’ interest in immunology can be categorised into six principal components. The measures constituting the various components are indicated in (Table 3).

8. Results

9. Demographics characteristics of participants

The total number of individuals who participated in the study was thirty-two (32) of which 38.7% were females while the remaining 61.3% were males. The number of participants in the 23–25 and

Table 1. KMO and Bartlett’s test

KMO and Bartlett’s Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.688
Bartlett’s Test of Sphericity	Approx. Chi-square	309.731
	Df	153
	P value	0.000

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Table 2. Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.234	34.635	34.635	6.234	34.635	34.635
2	2.612	14.513	49.148	2.612	14.513	49.148
3	2.47	13.722	62.87	2.47	13.722	62.87
4	1.308	7.267	70.137	1.308	7.267	70.137
5	1.107	6.151	76.288	1.107	6.151	76.288
6	1.023	5.684	81.972	1.023	5.684	81.972
7	0.603	3.35	85.322			
8	0.596	3.313	88.635			
9	0.53	2.947	91.582			
10	0.41	2.28	93.862			
11	0.315	1.748	95.61			
12	0.203	1.126	96.736			
13	0.18	0.999	97.735			
14	0.14	0.78	98.515			
15	0.091	0.507	99.023			
16	0.082	0.455	99.478			
17	0.069	0.386	99.864			
18	0.025	0.136	100			

28–35 age group were the highest accounting for 31.2% and 31.2%, respectively. Among these biomedical graduates, 46.9% were Biological Science graduates while 21.9% were Biochemistry graduates. Graduate students in other biological fields were also represented. Different graduating classes were represented thus 17.2% were first class graduates, 65.6% had second class upper and 17.2% had second class lower divisions.

To determine that factors that contribute to graduate students' interest in immunology, we performed PCA which revealed 6 factors. Component one (1) comprised students' perception while component 2 consists of instructor quality. However, component three (3) consists of variables relating to student's interest/motivation. Component four (4) consists of teaching methods, components five (5) covers teaching materials. Finally, component six (6) comprises teaching facilities. The component three (student interest/motivation) which represents graduate students' interest in immunology was used as the dependent variable with the remaining five factors as independent variables. Using the mean rating of the six components indicated that all factors were scored above the average with exception of component 1 (students' perception) as shown in Figure 1.

In addition, we conducted correlation and regression analysis using graduate students' interest in immunology as the dependent variable and the five remaining variables as the independent variables (Table 5). The correlation analysis showed a significant positive relationship between graduate students' interest in immunology and component 5 (teaching materials) ($p < 0.001$); however, the correlation between the students' interest and component 1, 2 and 6 (students' perception, instructor quality and facilities) were not statistically significant ($p > 0.05$) as indicated in Table 4. Students' interest in immunology showed a positive statistical correlation with component 4 (teaching methods). There was a negative correlation between students' perception and students' interest, teaching materials, teaching methods and teaching facilities. Of these, it was only the correlation between teaching methods and students' perception that was significant.

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Table 3. Rotated component matrix

Rotated Component Matrix

	Component					
	1	**2**	**3**	**4**	**5**	**6**
Learning Immunology is frustrating	0.643					
Lack of well-equipped immunology laboratory	0.811					
Poor illustration methods were used in teaching immunology	0.818					
Teachers lacked understanding of immunological concepts	0.737					
Immunology was abstractly taught	0.688					
Teachers did not have effective teaching materials		0.835				
Teachers linked immunological concept to immediate environment		0.802				
Teachers explained immunological concept clearly		0.589				
Teachers developed immunology course systematically		0.815				
The hours I spend learning Immunology are the ones I enjoy most			0.85			
I am highly interested in learning Immunology			0.877			
I love learning Immunology			0.798			
Teachers gave relevant examples				0.584		
Students are not involved in the teaching and learning of Immunology				0.755		
Teachers used relevant illustrations				0.727		
Student attach personal significance to the study of Immunology					0.803	
Provision of needed instructional materials for the study of Immunology					0.861	
Provision of library facility with relevant immunology books and learning materials						0.907

The results from the regression analysis as indicated in Table 6 show that graduate students' interest in immunology model using the five other components are significant and adequately predict graduate students' interest in immunology. The model thus suggests that the five other components can explain approximately 34% of the variance in graduate students' interest in immunology. The result further explains that although the five other components, when taken together significantly, predicts students' interest in immunology, only component 4 (teaching methods) and 5 (teaching materials) significantly contribute to the graduate students' interest in immunology (Table 6). The study performed exploratory factor analysis by examining the correlation patterns between the measures observed by the graduate students (Table 7). Exploratory factor analysis was used to explore the construct dimensions by examining the factor loadings of each dimension.

10. Discussion

Students' interest in immunology and other biomedical sciences has been unexploited over the years compared to other computational and physical sciences such as mathematics, statistics and physics (Abdul-Razzaq & Bushey, 2011; Arthur, Samuel, & Charles, 2017; Ashaari, Judi, Mohamed, & Wook, 2011, Carmichael, Callingham, Hay, & Watson, 2010, Trumper, 2006). In this study, we present some key factors, which influence interest among graduate students in immunology. These include students' perception, instructor quality/competence, interest/motivation, teaching methods/approach, availability of teaching materials and facilities. Here, we used principal

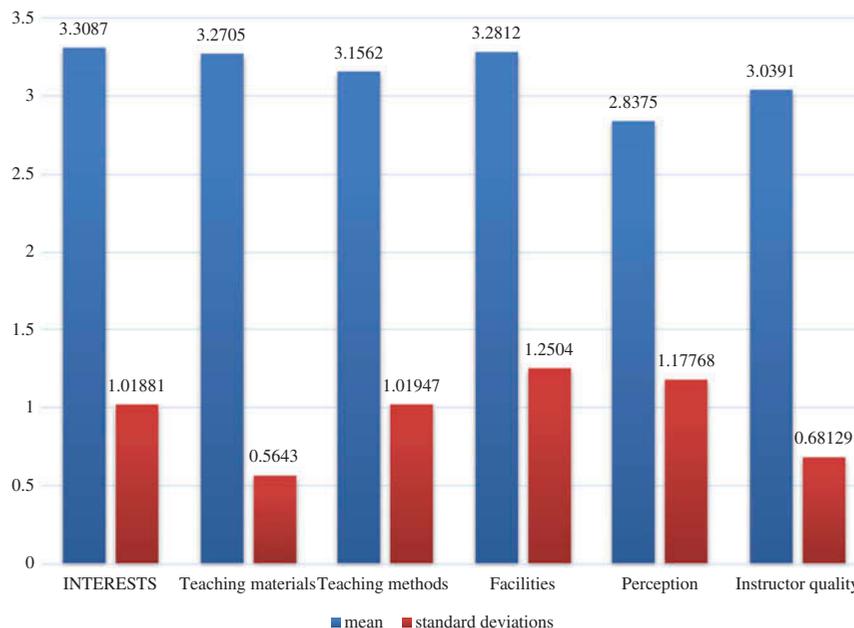cogent • education

Figure 1. A chart of mean and standard deviation of the factors.

Table 4. Descriptive statistics		
Descriptive Statistics		
	Mean	**Std. Deviation**
INTERESTS	3.3087	1.01881
Teaching materials	3.2705	0.5643
Teaching methods	3.1562	1.01947
Facilities	3.2812	1.2504
Perception	2.8375	1.17768
Instructor quality	3.0391	0.68129

Table 5. Correlation analysis of students' interest in immunology						
	INTERESTS	**FAC5**	**FAC4**	**FAC6**	**FAC1**	**FAC2**
INTERESTS	1					
Teaching materials	0.547**	1				
Teaching methods	0.422**	0.186	1			
Facilities	0.005	0.117	0.18	1		
Perception	−0.141	−0.035	−0.483**	−0.279	1	
Instructor quality	0.273	0.552**	0.392	0.11	−0.229	1

** $p < 0.005$.

components analysis to identify the main factors that drive graduate students' interest in immunology as a discipline. Of the six components that emerged, students' perception was found to be negatively correlated with students' interest. Implying that negative perception or misconception about immunology as a discipline can negatively affect students' interest which might lead to poor examination outcomes.

Kwarteng et al. (2017) recently reported high-interest levels in immunology among a cohort of graduate students which was independent of age and gender but correlated with career choices in

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Table 6. Test of model adequacy

			ANOVAb		
	Sum of squares	Df	Mean square	F	Sig.
Regression	14.285	5	2.857	4.152	.007
Residual	17.892	26	0.688		
Total	32.177	31			
R	R square	Adjusted R square			
.666a	0.444	0.337			

Table 7. Test of parameters significance

	Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		Std. Error	Beta		
(Constant)	−0.27	1.199		−0.225	0.824
Teaching materials	1.078	0.32	0.597	3.364	0.002
Teaching methods	0.412	0.177	0.413	2.33	0.028
Facilities	−0.095	0.125	−0.117	−0.762	0.453
Perception	0.00	0.15	0	−0.003	0.997
Instructor quality	−0.307	0.282	−0.205	−1.09	0.286

Ghana (Kwarteng et al., 2017). However, gender difference with regards to interest in life science disciplines has been reported by other studies (Prokop, Prokop, & Tunnicliffe, 2007; Uitto, Juuti, Lavonen, & Meisalo, 2006). Other factors such as educational level, economic status and educational level of parents/family/guardians have also been associated with students' interest, motivation and performance (Forsyth & Furlong; Salem et al., 2013, Thiele, Singleton, Pope, & Stanistreet, 2016).

In mathematics and other computational sciences, students' perception in addition to other dispositional factors such as poor academic self-concept, low self-esteem, negative attitudes or negative perceptions of students with learning disabilities may be associated with poor academic performances and social outcomes has been related to anxiety and poor performance (Arthur, Oduro, & Boadi, 2014; Marjorie, 1997; Yarhands, Samuel, & Charles, 2017). Some of the components that were captured under factor 1 (perception) included (i) learning immunology was frustrating (ii) immunology was abstractly taught (iii) poor illustrations methods were used in teaching immunology, which suggests students misconceptions of the course.

In relation to a recent study that compared students' perception and performance in a clinical laboratory immunology course (Ma et al., 2016), it was shown that students who participated in the problem-based learning (PBL) approach performed significantly better in the examination and had higher perception. Furthermore, 90.6% of the PBL group was of the view that PBL approach improved their learning and clinical problem-solving skills, better understanding and preparation towards examination. In that study, the authors reported that PBL improved learning motivation, clinical reasoning and problem-solving ability (Ma et al., 2016).

One of the important challenges facing biomedical and immunology educators is determining the most effective strategies for teaching both undergraduates and graduate students (Weber, Jensen, & Johnson, 2015). In the present study, we showed that effective teaching methods or

strategies were predictors of students' interest in immunology. Rather than sticking to the conventional ways of teaching, modern educators suggest the adoption of active learning methods in undergraduate Science, Technology, Engineering, Mathematics (STEM) programs, which have the potentials of increasing examination performances and cutting-down failure rates under traditional lecturing methods (Freeman et al., 2014; Haak, HilleRisLambers, Pitre, & Freeman, 2011).

Similarly, due to the continuously evolving and difficulty of immunology as a subject, some studies have focused on creating multimedia tools/platforms to support student's learning experience by facilitating visualisation and creation of mental models that support scientific comprehension (Crowther, 2012; Williams, 2016). One of such platforms 'virtual immunology' was reported to have improved students' motivation, interest and comprehension of both postgraduates and undergraduate students in Brazil (Berçot et al., 2013). In addition, among a cohort of Norwegian medical school students, it was shown that an e-learning package for studying medical immunology integrated into the traditional method of teaching promoted better examination outcomes (Boye, Moen, & Vik, 2012).

Furthermore, of the components that came up during the PCA in our study, teaching facilities was indicated as a predictor of graduate interest in immunology. Teaching and learning facilities may include textbooks, e-books, audio-visuals, software and hardware of educational technology, size of a classroom, sitting position and arrangement, availability of tables, chairs, chalkboards, shelves on which instruments for practical are arranged (Ong'amo, Ondigi, & Omariba, 2017). Immunology is a practical biomedical discipline which requires laboratory spaces and equipment to promote teaching and learning, that is transfer of skills. Growing evidence suggests that laboratory sessions may be avenues to enthuse and stimulate students' interest in immunology (Adams, 2009).

According to Adams, 2010, laboratory sessions are grounds for students to relate concepts learned in theory class to improve understanding of the course (Aguera et al., 2015). These sessions promote teamwork and help build the skill of scientific collaboration at an early age among students. On the other hand, according to the study by Weber *et al*, providing students with their own (personal) genomics data enhances interest and learning experience in molecular biology, therefore, suggesting the important role of availability of facilities and laboratories in promoting interest and learning of biomedical sciences such as immunology (Weber et al., 2015). Moreover, teaching materials such as the provision of textbooks were among the components, which showed up in the PCA as a predictor of student interest. This has been showed to improve academic performance (Ong'amo et al., 2017; Owoeye & Yara, 2011).

Our study showed that instructor quality was positively correlated with teaching materials, which suggest the interaction between teaching materials and teachers' competence in influencing students' interest and academic performance. The link between instructor quality and/or competence and students' interest has been established (Asiedu-Addo, Annan, & Arthur, 2016, Marsh, 2007; Murray, Douglas, Girdley, & Jarzemsky, 2010). A number of studies have also investigated the impact of students' perception of teachers competence on students' interest and learning (Obot, 1987; Pampaka & Williams, 2016).

The study had some limitations. These include the fact that PCA can only be used to identify potentially important contributors to the observed interest among study participants. PCA was unable to provide detailed information regarding quantitative correlations outcomes of interest. Additionally, the number of study participants included in the dataset is relatively small, limiting our ability to draw definitive conclusions from the data at hand.

11. Conclusions
The present study has demonstrated that PCA is a powerful statistical tool for analysing interest among biomedical graduate students in Ghana. We showed some key factors, which drive students'

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interest in immunology in Ghana to include: students' perception, instructor quality/competence, interest/motivation, teaching methods/approach, availability of teaching materials and facilities using PCA. Our findings suggest that in order to develop graduate students' interest in immunology in Ghana, a lot of resources (financial, technical and infrastructure) will have to be made available. Further investigations on interest in immunology will, therefore, be needed in order to attract graduates with a high interest in immunology in tertiary institutions, particularly in developing countries.

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