ATTITUDES OF BIOMEDICAL TECHNOLOGY STUDENTS TOWARDS MATHEMATICAL MODELLING

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ABSTRACT–This paper aims to determine the attitudes of biomedical technology students towards a mathematical modelling approach. Concerns have been raised by academia in the Health Sciences that students struggle to transfer their mathematical knowledge and skills to other contexts. The International Medical Informatics Association recommends curricula that aim to integrate knowledge and skills across disciplines. To help students connect mathematics with their own field of study, a mathematically-rich newspaper article was transformed into a realistic model-eliciting task. The sample comprises 38 first year students registered for a three year National Diploma in Biomedical Technology at the University of Johannesburg. To promote a collaborative learning culture, participants were divided into groups and had to complete a worksheet. As this was a maiden exposure to mathematical modelling, the task was delineated into sub-questions to guide students through the modelling process. Feedback from students regarding their attitudes towards mathematical modelling was collected and categorised using content analysis. Students felt more motivated working on a modelling task that promoted the usefulness of Mathematics in biomedical disciplines. The task aroused students’ interest in mathematical modelling and instilled problem-solving skills that created feelings of both enjoyment and anxiety.

Keywords: Biomedical technology; mathematical modelling; students’ attitudes.

1. INTRODUCTION AND BACKGROUND

Over the last decades, technological innovations and scientific discoveries had a significant impact on the quality of health care (Magjarevic, Lackovic, Bliznakov & Pallikarakis, 2010). New advancements in the medical and biomedical disciplines depend on the hard sciences, including Mathematics. The field of biomedical technology involves laboratory analyses of samples of blood, body tissue and body liquids (University of Johannesburg [UJ], 2015). Laboratory tests must be performed with scientific accuracy and precision since results of these tests are vital in the diagnosis of diseases or the prevention of imminent diseases (UJ, 2015a). Magjarevic et al. (2010, p. 2961) identify an urgent need for health professionals who exhibit multidisciplinary proficiencies. They report on projects in the European Union (EU) where “new curricula, teaching methods or materials” have been implemented. The authors envisage a fast growing biomedical engineering field posing different demands on educators for graduates with appropriate knowledge, skills and attitudes. Khan, Desjardins, Reba, Breazel and Viktorova (2013) critique mathematics educators for not facilitating pedagogical approaches that can enhance the relevance of mathematics in biomedical sciences. Khan et al. (2013, p. 15) report on the collaboration between Mathematics and Bioengineering departments aiming to establish “early” exposure of undergraduates to interdisciplinary applications of Mathematics. Using basic algebra, trigonometry and pre-calculus, the authors help students to solve real world problems involving orthopedic conditions and joint displacements. In the EU, efforts to improve the health of citizens highlighted the importance of the “integration of biological data and processes” and the production of knowledge and skills for suitable application in the biomedical fields (Magjarevic et al., 2010, p. 2960). Huang (2007, p. 99) emphasises the role of “cross-disciplinary sciences that integrate information from a variety of other theoretical sciences, including mathematics”. Harris, Bransford and Brophy (2002) call for adaptive teaching and learning approaches to improve the transfer of knowledge and skills to bioscience
settings – appropriate approaches involve authentic tasks that stimulate metacognition, reflection and sense-making as well as opportunities for collaboration and the use of technology.

In the South African setting, there is little research on the skills needed for the biomedical sciences and related professions, in particular the sort of skills required from the Mathematics discipline. Huang (2007) suggests a competency framework for medical and biomedical informatics degree courses that includes problem solving, modelling, communication skills and team skills. Mathematical modelling has the potential to develop students’ problem solving skills and transfer mathematics to daily life contexts (Çıltuş & Isik, 2013; Niss, 1989). Modelling activities promote deeper understanding of curricular concepts and a real world perspective can motivate students to learn mathematics (Zbiek & Conner, 2006). Kang (2012) sees the interdisciplinary potential of modelling as a desired classroom culture that should reach beyond prescribed textbooks.

Academics from the Faculty of Health Sciences at UJ are concerned that first year biomedical students struggle to transfer their mathematical knowledge and skills to their specialised fields of study. Calculations and Statistics is a semester module in the National Diploma in Biomedical Technology. This module is offered by the department of Applied Physics and Engineering Mathematics and aims to equip students with knowledge and skills for applications in biomedical contexts. To promote an interdisciplinary learning culture, the curriculum of the Calculations and Statistics module was revised in 2012 following a discussion between the various stakeholders (UJ, 2011; UJ 2015a). Although this re-alignment may be more diversified on face value, researchers believe that interdisciplinary applications should not be “contrived” word problems but based on genuine real world data (Cohen, 1995, p. 39; Department of Basic Education, 2011, p. 8). There is a need for greater in-depth knowledge within the core discipline of Mathematics and greater breadth across related bioscience disciplines (Huang, 2007). In order to establish whether students would embrace a mathematical modelling approach to help them transfer their Mathematics skills and knowledge to other biomedical fields, the following research question is posed:

What are the attitudes of biomedical students towards a mathematical modelling approach? In particular, what are the perceived skills elicited by a mathematical modelling approach? This paper therefore aims to explore the attitudes of first year biomedical students towards a mathematical modelling approach.

2. THEORETICAL PERSPECTIVES

2.1. Mathematical modelling

Mathematical modelling can be described as the activity of representing a real life phenomenon in terms of a mathematical model that can be analysed in order to understand and find a solution to the phenomenon (Ang, 2010). Fretz, Wu, Zhang, Davis, Krajcik and Soloway (2002, p. 567) value mathematical modelling for activities such as planning, identifying variables, evaluating, analysing, synthesising and critiquing. A modelling activity is characterized by “mathematizing (of) authentic situations” (Yerushalmi, 1997, p. 207) and peer-collaboration to create an inherent social activity (Zbiek & Conner, 2006).

2.2. Theoretical framework

The mathematical modelling framework developed by Galbraith and Stillman (2006) aims to critically analyse the modelling process by identifying bottlenecks between its progressive stages. Underpinning this paper, this modelling framework of Galbraith and Stillman is used to identify blockages in the modelling process and to detect the necessary skills required and attained. The framework structures the modelling process into distinct stages inter-linked by transitions as illustrated in Figure 1. The heavy arrows flowing in a counterclockwise direction represent the activities embedded in the transitions between successive stages. The modelling process originates
from a real world phenomenon observed in daily life. To facilitate the transition to the real world statement, it is necessary to understand the problem and to interpret the real world context in which the problem is situated. In the transition to the next stage – developing a mathematics model – a solution must be planned, assumptions must be made and variables and their relationships to one another must be identified to formulate equations. To this effect, paper-and-pencil graphs or diagrams can be used to interconnect and contextualise assumed relationships and equations. The activity of translating the real world problem into a mathematical model is what Freudenthal (1991) refers to as horizontal mathematising. This activity is crucial since it combines the assumptions, variables and parameters to fit the mathematical model coherently (Ang, 2010; Zbiek and Conner, 2006). The modelling process progresses to the stage where a mathematics solution is sought, this involves solving the modelled equation. The solving activity may involve mathematical algorithms, formulas, calculations and the use of technology. The next transition is to verify and reflect upon the obtained mathematics solution by reconciling its context with the real world meaning of the solution. In the final stage, the solution is validated by re-visiting the original real world problem statement to confirm or reject the mathematical solution, this is what Treffers (1993) refers to as vertical mathematising. The lighter arrows in Figure 1 suggest back-and-forth monitoring at each stage of the process. To this effect, Galbraith and Stillman use sub-tasks to help trace students’ progress at different stages of the modelling process.

2.3. Attitudes and skills
An attitude towards Mathematics signals a value-laden outlook of the discipline that affects the individual’s interest and motivation to engage with the subject (Gómez-Chacón, 2011). The author used a modelling approach to try and nurture the development of skills, including critical thinking and problem-solving skills. Papageorgiou (2009) is of the opinion that students’ mathematics attitudes are formed through their experiences in the classroom and that attitudes can influence the quality of their cognitive participation in tasks.

3. RESEARCH DESIGN AND METHODOLOGY
3.1. Paradigm and research approach
The study is undertaken with the credeence that knowledge is ever-changing since “the understandings of yesterday are not the same as those held today” (Shank, 2013, p. 189) and embraces the beliefs of pragmatism. This worldview can promote Mathematics as a discipline that is relevant and applicable to real world contexts in the field of biosciences.

The study is exploratory in its design; both quantitative and qualitative content analysis is used. According to Neuendorf (2002), content analysis is essentially quantitative in nature and regarded as
a summary of the message revealed by the data. However, Saldaña (2009, p. 204) describes content analysis as “qualitative and quantitative analysis of the contents of a data corpus”.

3.2. Participants
The 2015 cohort of 38 first year biomedical technology students participated in the study during a formal tutorial period of 90 minutes. This project was undertaken at the time when the straight line was the topic of discussion. Previous test scores were used to compile eight groups purposively. Each group comprised of four to five students and were structured as follows: one participant had a test score of less than 50%, one participant had a score between 50% and 70% and two to three participants had scores above 70%. None of these participants had prior knowledge or exposure to mathematical modelling. Group members were not to share their ideas with other groups. To create an informal and relaxed milieu, chairs were rearranged to form small workstations.

3.3. Data collection

3.3.1. The task
The framework of Galbraith and Stillman (2006) was used to design the modelling task. A newspaper article was selected to elucidate the real world applicability of the straight line in a biomedical context. The article describes an experiment performed on Mount Everest relating to the oxygen levels in human blood at different altitudes. The newspaper article is exhibited in Appendix A and represents the real world problem of the modelling process. The task was delineated into subtasks; three documents were handed out sequentially within an appropriate time interval. Firstly, each student received a copy of the article to read by themselves. They were encouraged to underline or highlight important details and make margin notes in order to visualise and interpret the article. Secondly, a planning sheet was handed out to each student with the problem statement, namely “Find an equation that models the oxygen levels in human blood at different altitudes above sea level”. From this point on, students worked collaboratively in their groups. To elicit understanding of the scenario (transition one of the modelling process), the planning sheet posed the question: “Is there more oxygen at sea level than at the top of a mountain?” Groups had to consolidate opinions and give a written response on the planning sheet. To plan a strategy (transition two), students had to contextualise their responses by designing a rough sketch to illustrate “how you picture this relationship”. To elicit reasonable assumptions (transition three), groups had to discuss two in-line statements to derive a “linear” model. Thirdly, a worksheet was distributed (See Appendix B). Four questions related to horizontal mathematising (transition four) where the model had to be constructed and subsequently solved (transition five). Three follow-up questions targeted vertical mathematising (transition six). Groups had to consolidate their draft documents and submit one planning sheet and one worksheet per group only.

3.3.2. Questionnaires
Students received a questionnaire with 14 open-ended questions but due to time limitations, questionnaires were completed two days later during the next lecture. Questions prompted opinions on experiences while doing the task, attitudes towards modelling, approach used and the over-all effect of the task (Gómez-Chacón, 2011).

3.3.3. Ethical considerations
The study guaranteed inclusiveness. Nobody was excluded as this study was undertaken during a scheduled tutorial period when students arrive with the expectation to revise, ask questions and work on their own. Written consent was obtained from all participants and confidentiality of data maintained. Students remained anonymous on the questionnaires.
3.3.4. Reliability, validity and trustworthiness

The planning and worksheets of each group were assessed and sent for moderation by a colleague. The inter-rater reliability was measured with Spearman’s rho since data is ordinal; rho values of between 0.94 and 0.99 were obtained and deemed acceptable (Neuendorf, 2002). Questionnaires (n=38) were coded by two coders, the inter-rater agreement was measured with Pearson’s product-moment correlation coefficient $r = 0.88$. Students’ open-ended comments confirmed the face validity since they perceived the task as a real life problem to be solved by finding a suitable model-equation. For content validity, consideration was given to the current curriculum topic – the straight line – and the appropriate level of expertise and skills embedded in the task. Exemplars from literature and expertise from colleagues were also incorporated to align appropriate questions for the planning and worksheets. Trustworthiness was preserved by using diverse instruments – planning sheets, worksheets and questionnaires. This allowed for triangulation of results (Creswell, 2014) that adds different dimensions to the study and improves credibility. The research setting and methods were described unambiguously.

4. DATA ANALYSIS AND DISCUSSION

4.1. Students’ work

Planning sheets of Group 7 and Group 2 represent unexpected discrepancies and are shown in Figure 2. Group 7’s understanding of the task was correct and clearly stated. This group designed a detailed graph to contextualise their thoughts and differentiated logically between the dependent variable (oxygen) and independent variable (altitude). It is conspicuous that the first in-line assumption (oxygen = 4.01kPa when altitude is 8400m) does not correlate with the two data points indicated in the sketch (A(0; 13) and B(8400; 2.55) respectively). The group was however unperturbed by this assumption in subsequent questions on the worksheet and it appears to be an initial estimate that was later-on adjusted. On the worksheet (exhibited in Appendix B), the mathematical model had to be derived by synthesising all information gathered from the planning sheet. Additional reflection questions on the worksheet targeted the interpretation and validation of the model. Overall, Group 7’s task was aligned with the real world phenomenon, they reflected on their calculations and logically interpreted solutions (Ang, 2010).

The planning sheet of Group 2 reveals that their understanding and contextualisation of the task was incoherent from the start. From their diagram it is evident that the group confused the minimum oxygen reading of 2.55kPa at an altitude of 8400m with a reading at 6400m. Interestingly, their in-line assumptions are correct but they failed to realise this inconsistency. Instead of using the correct assumptions, they reverted to the sketched plan and obtained an illogical model with bizarre solutions to the follow-up reflection questions. This transition involved the conversion between graphical and symbolical representations which can create cognitive difficulties (Arcavi, 2003). To translate the newspaper narrative (real world phenomenon) into a mathematical model is notoriously difficult (Galbraith and Stillman, 2006; Zbiek & Conner, 2006). Alerted thereof, this transition has purposively been delineated into sub-questions to guide students through this key stage of the modeling process – in fact, the entire planning sheet was dedicated to this purpose. However, this measure of prevention was in vain in the case of Group 2 as they failed to monitor and cross-reference their results at each stage as idealised by the lighter arrows of the theoretical framework. According to Barnes (2004, p. 54), “the traditional formal and authoritarian approach to teaching mathematics that has dominated in South African classrooms for a number of years has not afforded learners many opportunities to make use of horizontal mathematisation”.

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4.2. Task analysis

For assessment purposes, the planning sheet of each group was combined with their worksheet. Group numbers were allocated consecutively as teams handed in, meaning that Group 1 submitted first and Group 8 last. By delineating the task into sub-questions that correspond with each stage of the modelling process, the transitions between stages could be traced and activities identified. Activities for assessing the modelling process were motivated by the framework of Galbraith and Stillman and are shown in the columns of Table 1. For example, activity one is derived by considering the transition between the newspaper narrative (stage one of the framework) and the real world problem statement (stage two), this required students to understand the problem. Two raters assessed the task and set up rating codes for the six modelling activities.

<table>
<thead>
<tr>
<th>Modelling activities</th>
<th>Group</th>
<th>Understanding the problem (Problem statement)</th>
<th>Planning (Rough sketch)</th>
<th>Making assumptions (Fill-in questions)</th>
<th>Horizontal mathematising (Detailed sketch)</th>
<th>Solving (Three worksheet questions)</th>
<th>Vertical mathematising (Three worksheet questions)</th>
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</thead>
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<td>1</td>
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<tr>
<td>Rating codes: Unanswered=1; Incorrect=2; Partially correct=3; Correct=4.</td>
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</table>
Columns two and three of Table 1 reveal that the majority of groups managed to understand the article–problem and plan correctly. This indicates that most groups were able to contextualise the real world problem by translating it into a sentence describing the relationship between oxygen levels and altitude. This translation involves knowledge about functions relating dependent and independent variables, plotting graphs by selecting appropriate axes and assigning an increasing or decreasing function to the data. Real life phenomena are submerged in multiple contexts (Drijvers, 2000); therefore the translation from the real world to the mathematical world relies on various mathematical domains, representations and related interdisciplinary knowledge that must all be integrated (Ang, 2010).

The hint that the model should be linear meant that suitable data points had to be extracted (within an amount of freedom). Different altitudes and various oxygen levels were given in the article so that careful consideration was needed to identify appropriate assumptions. The assumption step was reasonably successful since all groups were rated ‘correct’ or ‘partially correct’. However, the transition between the assumption and horizontal mathematising steps revealed unexpected concerns. Group 8 struggled to contextualise that “sea level” implicates an altitude of 0m above sea level. Although their filled-in assumptions were correct, they misrepresented the data point (0, 13) as (6400, 13). A possible explanation can be a lack of everyday-life-experienced knowledge. The concatenating nature of the task meant that Group 8’s derived model was inappropriate and all other interpretational questions were wrong. Group 3 encountered a similar obstacle. They didn’t isolate the second assumption clearly as either 12kPa, 13kPa or 14kPa but gave the full range of 12-14kPa as stated in the article. This indecisiveness was not the blockage after all. In their follow-up calculations, they used the oxygen level correctly as 12kPa, but also failed to contextualise the meaning of “sea level”. Group 4 assumed oxygen to be the independent variable \( x \) and altitude to be the dependent variable \( y \). Regardless, their remaining two phases of constructing the model (horizontal mathematising and solving) and reflection (vertical mathematising) produced insensible results (such as a calculated oxygen level of 10226 kPa for a person living in Johannesburg) and is indicative of routine calculation done with no insight in the context of the task (Galbraith and Stillman, 2006).

The planning sheet was designed to guide students to the crucial step of the modelling cycle – horizontal mathematising. A dwindling number of successful groups can be observed in Table 1 between the assumptions and horizontal mathematising columns; this transition was the blockage for four of the eight groups. This is a surprising development since it was expected that correct or partially correct assumptions would manifest in the horizontal mathematising stage. In five of the eight groups, there is a sudden discrepancy between recorded in-line assumptions and graphical model-eliciting presentations. Of these five, Group 7 recovered but Groups 8, 3, 4 and 2 persisted without making sense of subsequent results. In these groups, there was a clear lack of skills to translate and mathematise the assumptions; subsequently they dissociated their mathematical solutions from the context of the article. Two contributing factors come to light. First, Ang (2010 p. 17) reports that “model formulation is the most challenging stage for students as it requires fairly high order thinking (and) inter-disciplinary knowledge” and second, classroom practices focus on routine and overly-cued problems which impair the development of skills to approach authentic problems (Harris et al., 2002, p. 36).

Groups 1, 5 and 6 (and to a certain extent Group 7) demonstrated logical step-by-step cognitive abilities and fulfilled the plan as set out on their planning sheets. Their models were graphically presented with appropriate data points and concisely worked into a linear model. All reflection questions were answered correctly. These groups transferred the problem from the real world to the mathematical world (Zbiek & Conner, 2006) through horizontal mathematising and justified the model through vertical mathematising. Conversely, the other five groups did not refer back to their
planning and assumptions confirming the theoretical framework prediction that blockages will occur when students do not monitor and reflect back-and-forth in-between stages (Galbraith & Stillman, 2006). The next section explores students’ attitudes and makes connections with the outcomes of the modelling activity.

4.3. Findings from the questionnaire data

Data from the individual questionnaires (n=38) were captured in Excel. First cycle coding on closed-ended questions with responses such as ‘Yes’ or ‘No’ were analysed quantitatively. This was followed by descriptive coding of open-ended questions. Saldaña (2009) sees descriptive codes in qualitative data as words or a string of words that capture a basic concept or trait. Attitudes, emotions, actions, experiences and attributes were identified in second cycle coding. Codes were clustered into themes to identify attitudes of students and the perceived skills elicited by the modelling task. This provides an answer to the research question, “What are the attitudes of biomedical technology students, in particular what are the perceived skills elicited by a modelling approach?” Four themes were identified and are discussed next.

4.3.1. Usefulness of mathematics

Of the 38 students who completed the questionnaire, 36 students (95%) came to realise the usefulness and application of the straight line in real life through this realistic real world problem. Coincidently, this study was undertaken six days after the earthquake tragically struck Nepal and Everest base camp in April 2015. The article aroused students’ interest unlike standard textbook problems. This contextually rich problem helped students to connect their subject matter knowledge of the straight line with reality. The practicality of modelling the straight line was affirmed by one student since it “makes one think out of the box like a biomedical technologist”. Career-centeredness was encouraged through this useful and applicable problem that students could identify with (Khan et al., 2013).

4.3.2. Renewed confidence

To formulate a mathematical model from the newspaper article was the most difficult part for 10 of the 38 students (26%). In order to contextualise the article and successfully construct a model, students needed to display skills in literacy, everyday-life-experiences, mathematical terminology and selectively extract data from the “messy” narrative (Galbraith and Stillman, 2006, p. 144). This didn’t deter students to face and overcome challenges as one student commented “I love the way it got me thinking, not like a student who just matriculated, but like a scientist”. Self-worth was evident in students’ comments such as “we are medical technologists and we are going to have to interpret graphs in labs so this is important”. The nature of real life data and the freedom to construct the model made students feel confused and unsure at times since they had no prior exposure to modelling activities. The lack of exposure to open-ended tasks reveals ingrained beliefs that Mathematics is either right or wrong (Schoenfeld, 1989). In this task, one student realised it was up to them to “sort out which points was which in terms of x-and y-axis” and to apply their theoretical knowledge to solve the problem. For many students the task was difficult at first, it is therefore promising that half of the groups managed to construct the model from muddled data.

4.3.3. Motivation

The opportunity to work as a team turned out to be very motivational for most students. Table 2 summarises students’ experiences on teamwork in a data matrix. Six recurring themes were identified from responses to the question “What was your general experience today about working in a team?” and quantified with magnitude coding (Saldaña, 2009). Separate yet related open-ended answers were inspected and cross-referenced for pluralistic meaning to compile a more comprehensive overview of each student’s experience.
### Table 2. General experiences of group work

<table>
<thead>
<tr>
<th></th>
<th>More motivated</th>
<th>Learn from others</th>
<th>Different opinions/approaches</th>
<th>Consolidate ideas</th>
<th>Communication</th>
<th>Saving time</th>
</tr>
</thead>
<tbody>
<tr>
<td>More motivated</td>
<td>34</td>
<td>25</td>
<td>18</td>
<td>7</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Learn from others</td>
<td>25</td>
<td>26</td>
<td>16</td>
<td>7</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Different opinions/approaches</td>
<td>18</td>
<td>16</td>
<td>19</td>
<td>5</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Consolidate ideas</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Communication</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Saving time</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
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</table>

The main diagonal of the data matrix reflects the student count for each of the six listed experiences towards group work. The first row indicates that 34 students were more motivated to work as a team, 25 students indicated that they were more motivated and could learn from others and 18 students mentioned that different opinions and approaches were beneficial in feeling more motivated. Another dominant intersection is teamwork that can be both motivational and contributing to knowledge production (25 students) and exposure to different opinions and approaches (16 students). Papageorgia (2009) observed the motivational effect inspired by group work and attributed this to the novelty of mathematical modelling. Additionally, we could confirm the view of Papageorgia in that this modelling task seemed particularly motivational to low-achievers who realised their own limitations and felt that they could learn from others and benefit from different opinions and approaches. “The group helped me a lot, I would have left not knowing what’s going on” and “broader views made me aware of my shortcomings”. A key strategy in the modelling process was to consolidate findings at each phase (Galbraith & Stillman, 2006). This required skills to contextualise, reflect and make new connections as established by Fretz et al. (2002).

### 4.3.4. Enjoyment

Responses to the question “Was this problem easy or hard, why do you say so?” oscillated between, hard or challenging (53%), neither hard nor easy (26%) and easy (21%). The task evoked feelings of anxiety and excitement which is expected in novel encounters (Hannula, 2002). The task was enjoyable and instilled a positive attitude towards mathematical modelling: “it was really nice” and “it was fun, I loved it”.

### 5. CONCLUSION

A modelling task prompted students to construct a mathematical model with biomedical contexts to ascertain their attitudes based on these experiences and the perceived skills elicited by this modelling activity. Worksheet analysis indicated that the modelling task could elicit cognitive knowledge and skills. It was encouraging that many groups managed to complete the task successfully without prior modelling experience. By solving a realistic real world problem, affective attitudes such as the usefulness of Mathematics, connecting subject matter knowledge to real life contexts and career-centeredness were identified. Emotional attitudes toward mathematical modelling were manifested in students’ reports of self-confidence, enjoyment, motivation and their appreciation of the exposure. The affordances offered by this mathematical modelling task enabled students to articulate their mathematical knowledge and skills in biomedical contexts. A limitation of the study was that only one modelling task was given during the semester and results are therefore not generalisable. However, results from this pilot study hold merits for further investigations on
how to capitalise on the initial eagerness of students and their apparent motivation to learn through a modelling approach. Cognisant of the belief that attitudes are cemented through repeated experiences (Papageorgiou, 2009), we see potential for modelling activities when infused into the curriculum of biomedical technologists.

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APPENDIX A: THE NEWSPAPER ARTICLE

The Telegraph
by Rebecca Smith, Medical Editor
3:49PM GMT 06 Jan 2009
by Rebecca Smith, Medical Edit

Doctors near top of Everest record lowest ever blood oxygen levels.

Mountaineering doctors climbed to the top of Everest to take blood in experiments to aid the treatment of critically ill patients. The team recorded the lowest levels of oxygen in human blood after scaling the world’s highest peak. The Caudwell Xtreme Everest team of climbing doctors, from University College London, braved the sub-zero temperatures near the summit and unzipped their suits in order to take blood from their own femoral arteries in the groin. They had hoped to take the samples while at the very top of Everest but conditions were too severe with temperatures at minus 25 degrees and winds of more than 20 knots. Having descended a short distance from the summit, the doctors took the samples at 8,400 metres above sea-level. They then descended to their camp at 6,400 metres to analyse the blood within the required two hours. The expedition found the average arterial oxygen level to be 3.28 kilopascals (kPa), which is unit of pressure. The lowest value recorded was 2.55 kPa whereas the normal value in humans is 12-14 kPa. Dr Mike Grocott, a UCL Senior Lecturer in Critical Care Medicine and expedition leader said: “This is far below what was previously thought possible. “Previous speculation had been that humans could not function if the levels dropped below 3.9 kPa.”

APPENDIX B: THE WORKSHEET

Now answer the following questions:

1. Make a detailed sketch (it can be similar to the one above, or different):
   a. Label your horizontal and vertical axes.
   b. Indicate two appropriate coordinates (from your assumptions).

2. Find the gradient of the line through these two points.
   (State the two coordinates you are using)

3. Find the value of the intercept on the vertical axis (c).

4. Write down the equation of the straight line.

5. What is the minimum altitude that will no longer sustain any human life?

6. At what altitude would an oxygen level of 8kPa be reached?

7. If the altitude of Johannesburg is 1753m above sea level, what would the oxygen level of a typical person living in Johannesburg be according to the equation obtained above?