

INFUSING MATHEMATICAL MODELLING TASKS INTO A TRADITIONAL CURRICULUM: ON HABITS AND HABITUS

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ABSTRACT– This paper aims to explore the habits and habitus of Biomedical Technology students when they are exposed to novel mathematical modelling tasks. Mathematical modelling involves open-ended real world problems which require a degree of creativity. Such non-routine tasks may challenge established habits formed within traditional curricula. Students act according to their teaching and learning environment which in turn becomes a catalyst for habit formation and habitus. Four mathematical modelling tasks were infused into the traditional Mathematics curriculum during the first semester of 2016. The sample comprised 51 first year students registered for a three-year National Diploma in Biomedical Technology at a South African University. Data was collected with an open-ended questionnaire and analysed with a directed approach to content analysis. As a follow up, a second questionnaire comprised contrast pairs on semantic differential scales. Principal component analysis confirmed four components labelled modification, exploration, affiliation and aspiration which explained 60.6% of the total variance. The relevance of social activities and group affiliation corresponded with the willingness to change habits and the evolvment of habitus. With dispositions rooted in old-school routines, the modelling tasks challenged students to adjust habits according to different demands. Modelling tasks stirred students’ scientific curiosity and affirmed their career-orientedness. Results showed that students’ habitus could be enhanced through the transformation of habits imposed by mathematical modelling tasks, infused into a traditional curriculum.

Keywords: Biomedical technology; mathematical modelling; habits; habitus; semantic differential.

1. INTRODUCTION AND BACKGROUND

Traditional teaching and learning approaches have dominated Mathematics classrooms where knowledge bases function in isolation from other disciplines (Humphrey, Coté, Walton, et al., 2005). Paradoxically, the biomedical industry demands technologists with attitudes and competencies to solve real world problems of an interdisciplinary nature. The experiences students accumulate depend on teaching and learning methods, the kind of tasks, the learning materials and the social organisation of the classroom (Dewey, 1938). In turn, these experiences influence students’ habits and dispositions (Schoenfeld, 1992). Habits and dispositions stimulate the way students see the world, frame the way they think about mathematics, the way it is done and its future value (Schoenfeld, 1992), a concept which Bourdieu (1984) refers to as habitus.

The applications of Mathematics in the biomedical disciplines are diverse. In particular, Humphrey et al. (2005) value mathematical modelling and the collection, analysis and interpretation of data. Schoenfeld (1992) perceives day-to-day phenomena as contexts for mathematical modelling that are often overlooked. Problem solving should go beyond example-to-exercise classroom routines and include open-ended tasks that demand non procedural processes.

First year biomedical technology students follow a one-semester module which aims to develop knowledge and skills applicable to biomedical contexts. A traditional teaching and learning style is followed with five contact periods per week. However, a pilot project conducted in 2015 reports that students are eager to learn in an environment that elicits new experiences based on a mathematical modelling approach (Kotze, Jacobs & Spangenberg, 2015). The current study aims to explore the habits

and habitus of biomedical technology students while performing mathematical modelling tasks for the first time. The following research questions are posed:

What are the main components that structure biomedical students' habits and habitus when they are exposed to novel mathematical modelling tasks? What dispositions, related to habits and habitus, are operationalised as a result of mathematical modelling tasks?

2. THEORETICAL PERSPECTIVES

2.1. Mathematical modelling

A mathematical modelling approach can be described as the activity of translating a real life problem into a mathematical model so as to find a meaningful solution (Ang, 2010). The mathematical modelling community has revered the diversity of competencies embedded in this teaching and learning approach: social collaborations during group work, mathematically-sound communication, metacognition, the use of technology and critical reflection (Kaiser & Brand, 2015). Galbraith (2015) is however cautious about efforts from educators that overtax already crammed curricula with “often contrived” initiatives boosted by “feel good” statements from participants (p. 348). Sadly, mathematical modelling has not reached its full potential in “complex” educational systems where it is competing as a “new product” (Pollak, 2015, p. 265) and therefore still regarded as unconventional. This may be due to the considerable effort required to develop modelling tasks, the lack of teacher training (Ang, 2010) and its time-consuming nature.

2.2. Habits

A habit is seen as the “more or less fixed way of doing things” and extends to the formation of emotional and intellectual attitudes (Dewey, 1944, p. 27). Since repetition is the product of constant conditions, habit formation is initially in a phase of inertia. As students transact with a different environment, there is a modification in their internal habit structures to re-align with the new environment (Cutchin, Aldrich, Bailliard & Coppola, 2008). This modification also directs future actions since new experiences influence attitudes and goals (Dewey, 1944). Habits that are being sustained, further developed and enacted, become valid (Dewey, 1938). Once a habit is developed, it becomes a general principle, a way to behave in a particular way in further activities. Contrarily, habits become invalid if not sustained since habits are founded in routines, the common ways in which a person acts, but are not based on a solitary act. The dichotomy of habit-formation and habit-isolation stems from the continuity or discontinuity of experiences. For Dewey (1944, p. 27), continuity of experiences is when “every experience both takes up something from those which have gone before and modifies in some way the quality of those which come after”. In contrast,

experiences may be so disconnected from one another that, while each is agreeable or even exciting in itself, they are not linked cumulatively to one another. Each experience may be lively, vivid, and “interesting”, and yet their disconnectedness may artificially generate dispersive, disintegrated, centrifugal habits. The consequence of formation of such habits is the inability to control future experiences (p. 14).

In this study, students' habits are explored as they pass from a traditional teaching and learning environment to a mathematical modelling environment and how habit structures are adjusted and/or modified according to non-routine demands.

2.3 Habitus

The oeuvre of sociologist Pierre Bourdieu (1984) on capital, field and habitus has been applied to various educational contexts. From a mathematical perspective, Bourdieu's notion of *capital* can be interpreted as the resources that can be used in an educational setting or *field* (Morberg, Lagerström & Dellve, 2012). In particular, embodied cultural capital represents students' acquired characteristics, competencies, values, preferences, behaviours and dispositions (Czerniewicz & Brown, 2013). Cultural capital can potentially create privileged opportunities for certain groups within society and thus

legitimise dominant cultures (Morberg et al., 2012). To this end, social capital is the social status of students in terms of their connections or position within social groups. An interplay between cultural and social capital is ever-present since dispositions reflect “the social context in which they were acquired” (Reay, 2004, p. 435). Dumais (2002) reasons that although cultural capital has been linked to educational achievements, the habitus of students is as important. According to Bourdieu (1998, p. 81, quoted in Reay, 2004, p. 432), the habitus

is a socialised body. A structured body, a body which has incorporated the immanent structures of the world or of a particular sector of that world – a field – and which structures the perception of that world as well as action in that world.

Habitus therefore serves as a framework that reflects acquired perceptions and dispositions as manifested in the field where it was constructed; it also directs future actions that can potentially transcend prior conditions (Reay, 2004). When external influences are internalised, habitus shapes students’ dispositions, aspirations and expectations (Cutchin et al., 2008). The shaping of students’ worlds and how they navigate through accessible cultural and social capital, depend on their orientation towards habitus (Dumais, 2002). The porousness of habitus makes it possible for students to adapt to new conditions, thereby transforming the habitus to embody new experiences that influence students’ expectations (Reay, 2004) and creative processes (Cutchin et al., 2008). An interplay between past and present creates a continuum in which habitus can help establish the field as prelude to meaningful, value-laden practices. A sense of value and a belief in their abilities can navigate students’ cultural and social trajectories (Quaye, 2014).

In this study, the notion of habitus is explored on a past-to-present continuum by focusing on students’ dispositions in and responsiveness to a mathematical modelling environment as field. Since attitudes and values are deeply rooted, students are inclined “to do, think and imagine in the perspective of the past” (Morberg et al., 2012, p. 356). Cultural capital is represented by modelling processes and its potentialities, whereas social capital is represented by students’ interaction during group work and this effect on individuals. The potential role of habitus in the transition from conventional teachings to a modelling approach is explored as students’ structure of future prospects and academic success (Dumais, 2002; Reay, 2004).

3. RESEARCH DESIGN AND METHODOLOGY

3.1. Paradigm and research approach

This study is epistemologically underpinned by a contextualist point of view (Schraw, 2013). From a contextualist position, students are encouraged to acquire knowledge that is applicable, useable and relevant to their studies and future world of work. This view subscribes to the belief that certain skills can only be acquired by working with other students; that students must be given the opportunity to pool their resources and learn in an environment where new truths can transactionally be tabled. Especially during the early years, “learning goals and practices are affected by institutional and classroom expectations” (Schraw, 2013, p. 7).

The study follows an exploratory sequential mixed methods design (Creswell, 2014). Quantitatively, principal component analysis (PCA) was followed by a directed approach to qualitative content analysis. As an analytic technique, PCA computes the components within a data set and analyse how variables contribute to each component (Field, 2009). Williams, Brown and Onsmann (2012) consider PCA as the preferred method to interpret self-reporting questionnaires. First, PCA was used to extract prominent components of students’ habits and habitus following exposure to four mathematical modelling tasks. This would answer the first research question: *What are the main components that structure biomedical students’ habits and habitus when they are exposed to novel mathematical modelling tasks?* Subsequently, these components were further explored with a directed approach to content analysis. Hsieh and Shannon (2005) describe a directed approach to content analysis as a structured extension of existing research that further analyses variables of interest. This qualitative

method would answer the second research question: *What dispositions, related to habits and habitus, are operationalised as a result of mathematical modelling tasks?* The rationale for using two questionnaires was to link items with common themes across instruments (Schraw, 2013). The order in which the data was collected was reversed during the analysis. In this sequence, the main components could first be identified quantitatively and then be further explored qualitatively (Creswell, 2014).

3.2. Participants

A cohort of 51 first year biomedical technology students partook in this study during the first semester of 2016. Modelling tasks were scheduled during 90-minute tutorial periods at two-week intervals. Unlike traditional lectures where students always work by themselves, small groups were formed for modelling purposes. Using test results, ten groups with five students each were proportionally stratified to include low, average and high performers in each group. Students remained in the same group throughout the semester. All participants were hitherto unexposed to mathematical modelling.

3.3. Data collection

3.3.1. Mathematical modelling tasks

Although it is not the aim of this paper to report on the modelling tasks per se, a brief description is given to frame the context. For each of the four tasks, a newspaper article was sourced that described a real world problem. Task 1 related to a project where school children exchange recyclables for 'Moolas' which in turn is exchanged for 'valuables' such as stationary and food items. The newspaper article for Task 1 appears in Appendix A. In the task, students had to create a poster that displays the Moola trade-values of recyclables for valuables. In Task 2, students had to create a three-month budget for purchases at a garden centre. Task 3 related to the mysterious disappearance of boats and airplanes over the Bermuda Triangle. Students had to source the GPS coordinates of the fictitious triangle to calculate the area of the triangle using a determinant algorithm. Task 4 described an experiment on Mount Everest that relates to the oxygen levels in human blood at different altitudes; this task was described in detail in Kotze et al. (2015). All tasks were designed according to principles that promote modelling competencies (Galbraith, 2015).

3.3.2. Semantic differential questionnaire

Semantic differentials measure a concept on bipolar scales using suggested contrasting adjectives (Heise, 1970). The focus of the semantic differential questionnaire is to find structure in students' habits and habitus as suggested by bipolar contrasting pairs (Schraw, 2013). Drawing on the scale designs of Stahl and Bromme (2007), the questionnaire comprises several subsections relating to the four mathematical modelling tasks. A shortened version of the questionnaire appears in Table 1 showing subsections and selected semantic differentials related to each subsection.

The tasks were:						Concept tested:	
Simple	<input type="checkbox"/>	Complex Unfamiliar Time-consuming Blurred	The nature of tasks				
Familiar	<input type="checkbox"/>						
Hurried	<input type="checkbox"/>						
Structured	<input type="checkbox"/>						
The tasks required me to:							
Use given data	<input type="checkbox"/>	Extract data	Competencies required				
Think creatively	<input type="checkbox"/>	Think conventionally					
The processes we had to follow were:							
Specific	<input type="checkbox"/>	Non-specific	Processes to be followed				
Normal	<input type="checkbox"/>	Different					
Fixed	<input type="checkbox"/>	Changeable					
Working in a group made me feel:							
Confused	<input type="checkbox"/>	Understanding	Feelings about group work				
Productive	<input type="checkbox"/>	Unproductive					
Certain	<input type="checkbox"/>	Uncertain					
What I value about these tasks:							
Following routines	<input type="checkbox"/>	Adjusting routines	Value of tasks				
Critical thinking	<input type="checkbox"/>	Stereotyped thinking					
Correct answers	<input type="checkbox"/>	Sensible answers					
Tradition	<input type="checkbox"/>	Discovery					
Feel curious	<input type="checkbox"/>	Feel disinterested					
As study objectives, I:							
Want to pass well	<input type="checkbox"/>	Just want to pass	Study objectives				
Often think about my career	<input type="checkbox"/>	Never think about my career					
Focus on my studies	<input type="checkbox"/>	Relax about my studies					
I believe:							
A good job depends on good grades	<input type="checkbox"/>	A good job doesn't depend on good grades	Career prospects and beliefs				
Education is life-changing	<input type="checkbox"/>	Education cannot change one's life					

Table 1: Subsections and typical variables of the semantic differential questionnaire.

These include subsections that are essential to mathematical modelling principles (Kaiser & Brand, 2015) namely 1) nature of the tasks, 2) competencies required, 3) processes to be followed, 4) feelings about group work, 5) value of tasks, 6) personal study objectives and 7) career prospects and beliefs. Each subsection is measured with associated semantic differentials which can prospectively add a dimension to the two concepts under investigation, namely habits and habitus (Heise, 1970).

Semantic differentials were recorded on a scale from 1 (low) to 5 (high). Contrasting pairs were randomly aligned in the direction from a negative outlook (low=1) to a positive outlook (high=5) or vice

versa. For example, to contrast *purposeful* on the lower end of the scale with *aimless* on the upper end suggests an outlook in a positive to negative direction. In such cases, the suggested positive to negative direction of the scales were reverse coded such that aimless would be rated as 1 and purposeful as 5. All variables were consistently subjected to a low-high scale. The questionnaire was collected at the end of the semester after all modelling tasks were completed to allow for insights into the overall exposure to such tasks.

3.3.3. Open-ended questionnaire

After the first modelling task, students were asked to complete an open-ended questionnaire with 14 questions; see Appendix B. The questions explored students' dispositions on habits and habitus in relation to the modelling approach.

3.4. Ethical considerations

All activities were scheduled during tutorial periods which guaranteed equal participation. Students remained anonymous on both questionnaires.

3.5. Reliability, validity and trustworthiness

The reliability of the semantic differential questionnaire was measured as .836 based on the initial 53 standardised items. After adjustments as suggested by principal component analysis (PCA), an alpha value of .803 was calculated for the remaining 23 standardised items (Field, 2009). After extraction of the principal components, individual component reliabilities were calculated as displayed in Table 2.

Table 2: Reliability of extracted categories.

	Cronbach α
Component 1	.902
Component 2	.840
Component 3	.750
Component 4	.660
Overall	.803

The PCA research design is deemed appropriate in securing construct validity (Williams, Brown & Onsmann, 2012). IBM SPSS Statistics vs 23 was used for the statistical analysis. Content validity of the standard differential questionnaire was safeguarded by including idiosyncratic modelling-qualities as bipolar pairs. Students' responses that reflected their opinions and experiences established the face validity of the open-ended questionnaire. Trustworthiness was operationalised with the use of two questionnaires.

4. DATA ANALYSIS AND DISCUSSION

4.1. Quantitative principal component analysis

4.1.1. Suitability and extraction criteria

Semantic differential questionnaires ($n=51$) were analysed with principal component analysis (PCA). To access the suitability of the data for PCA, Field (2009) recommends the following tests: Firstly, in samples less than 100, communalities greater than .6 is regarded as adequate. Extracted communalities for all the semantic differential variables on the questionnaire ranged between .631 and .904 and thus well within this limit. Secondly, the suitability of data for principal component analysis was inspected with the correlation matrix. The Pearson correlation coefficients were scanned for negative and small r – values which would indicate to poor correlations. Variables with few inter-item correlations above $r=.3$ were suspect and iteratively eliminated. Thirdly, the sampling adequacy was measured with the Kaiser-Meyer-Olkin (KMO) statistic and found to be .585, marginally above the acceptable lower bound of .50 (Field, 2009), hence data passes the KMO test. Bartlett's Test of Sphericity compares how closely the correlation matrix correspond with an identity matrix; a close

resemblance would indicate to small correlations between variables and thus discredit the data. Bartlett's Test of Sphericity would be significant if $p < .05$. The data passed the test with $\chi^2 (253) = 659.557, p < .001$. The tests confirmed that correlations between variables are large enough to conduct PCA (Field, 2009).

Principal component analysis is the most commonly used extraction method in exploratory factor analysis (Field, 2009). Almost identical results were obtained with principal axis factoring and principal component analysis with orthogonal rotation (varimax). Three criteria for extraction were controlled for (Williams, Brown & Onsmann, 2012). Firstly, the default setting in SPSS matches Kaiser's criterion that stipulates a minimum eigenvalue of one. Secondly, a scree plot assists in choosing which of the competing components to retain. Only the largest eigenvalues are retained while the smaller eigenvalues become redundant. Visually, components can be aligned with two line segments to form an elbow that bends in the point of inflection. A guideline is to retain only those components above the point of inflection. Thirdly, the total variance explained by the principal components would ideally be above 50%. The original 53 variables on the SD questionnaire were sequentially reduced according to these criteria till component loadings reached r values greater than .30. The scree plot is shown in Figure 1 but was rather ambiguous; either four or eight components could be extracted. Consulting the rotated component matrix, it became clear that there were less than four variables that loaded onto components five to eight; therefore, these components were not considered (Field, 2009). Besides, Kaiser's criterion would be breached if eight components were to be considered. Conclusively, only four principal components were extracted from the remaining 23 variables. The stable four-component structure explained 60.637% of the cumulative percentage of variance (Field, 2009).

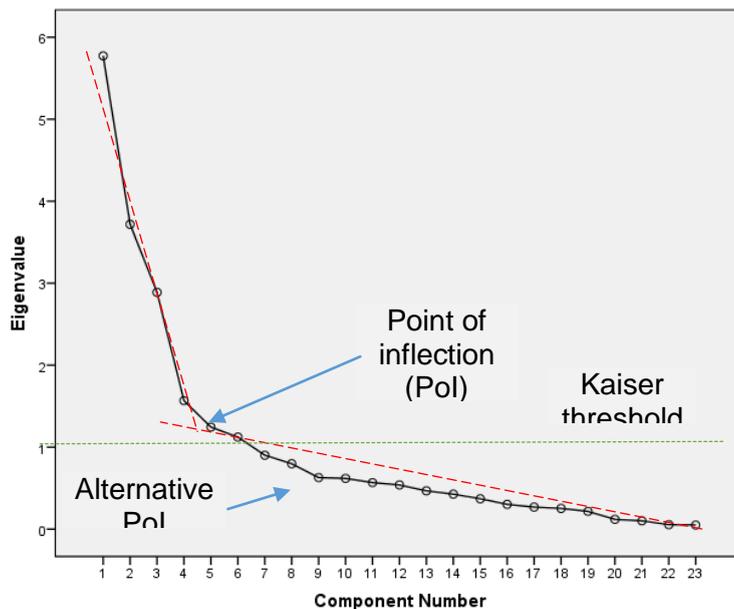


Figure 8: Scree plot suggesting four principal components.

4.1.2. Labelling and interpretation of principal components

The variables that loaded onto each component were examined for common themes that could be used as labels (Field, 2009). This would provide an answer to the first research question "What are the main components that structure biomedical students' habits and habitus when they are exposed to novel mathematical modelling tasks?"

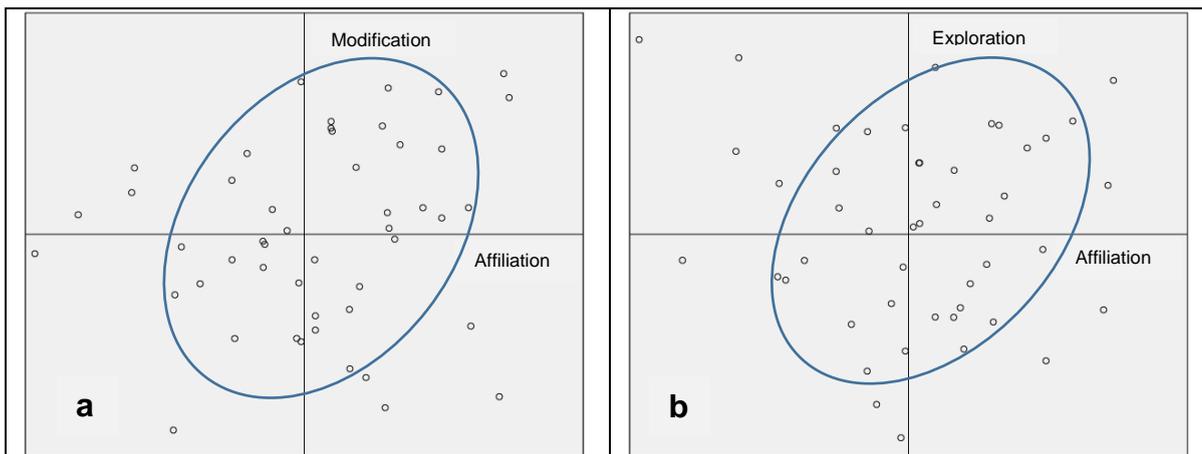
Labelling is a "subjective, theoretical, and inductive process" (Williams, Brown & Onsmann, 2012, p. 9). Table 2 summarises the four components, some of the semantic differentials that loaded onto each component and the total percentage variance explained. Nine variables loaded onto component 1 which explained 25.1% of the total variance. These variables were all related to the questionnaire subsection relating to group work. The label *affiliation* describes the semantic adjectives relating to

students' dispositions when working in a group. Six variables loaded onto component 2, explaining 16.2% of the total variance. These semantic differentials related to students' career prospects, beliefs and study objectives, hence this component was labeled *aspiration*. Component 3 loaded from five semantic differentials, explaining 12.5% of the total variance. These adjectives related to processes and routines followed in the modelling tasks and was labeled *modification*. Component 4 assessed students' perceptions on the nature of mathematical modelling tasks and was labeled *exploration*. Habitus was operationalised as students' study objectives and career *aspirations* (Quaye, 2014), but also students' dispositions on social *affiliations*. The notion of habits was invited by the components *modification* and *exploration* which measure students' dispositions based on modelling processes.

Table 2: Key semantic differentials that loaded significantly onto four components.

Component 1 -Affiliation (Variance-25.1%)	Component 2 -Aspiration (Variance-16.2%)	Component 3 -Modification (Variance-12.5%)	Component 4 -Exploration (Variance-6.8%)
Motivated ↔ Unmotivated	Relaxed ↔ Focused (studies)	Tradition ↔ Discovery (processes)	Familiar ↔ Unfamiliar (tasks)
Disappointed ↔ Stimulated	Just pass ↔ Pass well	Specified ↔ Non-specific (processes)	Textbook-like ↔ Unlike textbook (tasks)
Unreceptive ↔ Receptive	Do not value ↔ Value (studies)	Normal ↔ Different (processes)	Structured ↔ Blurred (tasks)
Disinterested ↔ Curious	Never ↔ Often (think of career)	Follow ↔ Adjust (routines)	
Enthusiastic ↔ Unenthusiastic	No change ↔ Life- changing (education)	Correct ↔ Sensible (answers)	
Comfortable ↔ Uncomfortable	Stereotyped ↔ Critical (thinking)		

Component scores were generated in SPSS using the Anderson-Rubin algorithm to measure students' placements on each of the four components (Field, 2009). Component scores have a mean of 0 and unit standard deviation. Figure 2 shows four bi-plots where component scores were mapped in a 2-D plane as scatterplots (Hsu, Chuang & Chang, 2000). Each circle in the scatterplot represents the component score coordinates of a particular student; the 2-D coordinates correspond with PCA-extracted components as indicated on the axes. Ellipses are superimposed onto concentration clouds with high student densities which assist in identifying correlations.



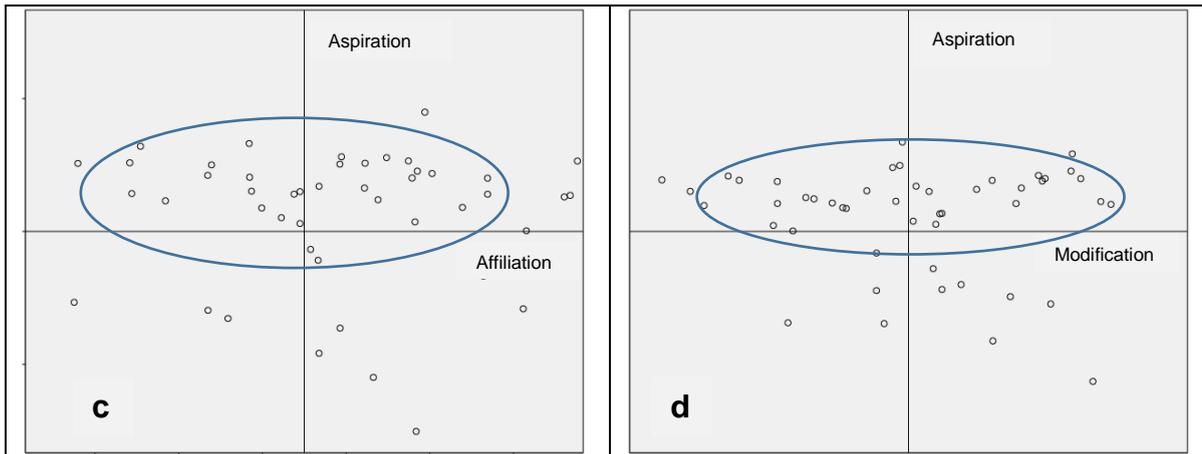


Figure 9: Concentration ellipses in 2-D component space.

Figures 2a and 2b indicate almost equal concentrations of students in all four quadrants. However, the tilted shape of the respective concentration ellipses suggests a slight domination towards the first quadrants, reflecting students who value group work and demonstrate positive dispositions towards modification and exploration. As such, students represented by the first quadrants of Figures 2a and 2b, afforded group work as social capital to accrue cultural capital underpinned by dispositions which stem from semantic differentials likened to scientific curiosity. The new modelling environment posed new needs, if reached, students critically assessed old processes and realised new possibilities (Dewey, 1938). The smallest cloud concentrations are located in the second quadrants of Figures 2a and 2b and represent students with negative dispositions towards affiliation. Apparently, they did not benefit from group work and preferred to work alone, but were tangentially stimulated by scientific inquiry. Students represented in the third and fourth quadrants of Figures 2a and 2b are in a phase of inertia (Dewey, 1938) regarding their dispositions towards modification and exploration, a phenomenon not unexpected in a new learning environment. The students in quadrant 4 of Figures 2a and 2b are positively affiliated towards group work but negatively dispositioned towards modification and exploration. This indicate that although these students benefitted from group work, their tendencies to modify actions and explore new possibilities were not paralleled.

In Figures 2c and 2d, the concentration ellipses are elongated; both bi-plots reveal mainly positive scores on the aspiration-axes. This indicates that regardless of being positively or negatively affiliated to a group or modification processes, aspiration levels were mainly positive. As such, most students' aspirations towards their future corresponded with the relevance of group affiliation and willingness to modify habits to accommodate new challenges, an indication of an evolving habitus. The students in quadrant 2 of Figure 2c have positive dispositions towards aspiration but also prefer to work alone. Similarly, quadrant 2 of Figure 2d represents students with negative dispositions towards modification as they don't regard it necessary to change their routines in order to achieve their aspirations.

The semantic differential questionnaire can at most *suggest* opposing adjectives from which students were to describe their feelings. It would be misleading to give the impression that the chosen feelings were indeed *felt* (Dewey, 1938). To fill this gap, the qualitative feelings of students are now described in their *own* semantics.

4.2. Directed approach to content analysis

A directed approach to content analysis was used to analyse the open-ended questionnaires. Unlike conventional content analysis, a directed approach utilises codes derived from prior analyses which are therefore readily available (Hsieh & Shannon, 2005). The open-ended questionnaires were explored for students' dispositions on processes followed during the modelling tasks. Data was first captured in Excel, thereupon the semantic differentials which loaded onto the four components (see Table 2) were used as codes. Data was scrutinized for both positive and negative views to provide balanced perspectives (Czerniewicz & Brown, 2013). This qualitative method provides an answer to the second

research question, “*What dispositions, related to habits and habitus, are operationalised as a result of mathematical modelling tasks?*”

4.2.1. Component 1 - Modification

Habits are forged by traditional ways of acting within a learning environment (Dewey, 1938). When a new learning environment acts as stimulus, it creates potential for traditional ways to be modified. For Dewey, the formation of a new habit is initially in a state of unawareness; “I have realised that in life we always apply matrices but wasn't aware of it”. Upon reflecting on the first modelling task, students realise *what* has been done and *how* it was done. When new ways of doing are noted and verbalised, they become valid (Dewey, 1938). Shortcomings in the old ways of doing are realised when the required future behaviour becomes clear. “I couldn't do this task without my group, it needed critical thinking”. Habits are modified when a “fixation” on new ways of doing goes in concert with a “weakening” of old behavioural activities (Dewey, 1938, p. 31-32). “It inspired me to be inquisitive and expand my horizons to become smart”. This modification also directs future actions since new experiences influence attitudes and goals (Dewey, 1944). It is foreseeable that the development of new behaviours is closely affected by students' individual perceptions of the modelling environment (Dewey, 1938). Students had mixed attitudes towards modelling which explains why some were reluctant and others keen to modify their ways of doing. “It allows you to see things in a different way and do things in different ways” which contrasts with “I would not want to do more of these tasks because we are used to the normal way of doing things and this method will take time to get used to”.

4.2.2. Component 2 – Exploration

Dewey (1938) regards habit formation to be an ongoing interaction between students and their learning environment. This interaction does not terminate in repetition, instead, it is a continuous search and exploration that never becomes entirely stagnant. Dewey (1938) claims that initially, habit formation is in a state of inertia. When students are exposed to a new environment, they search for the known in the realm of the unknown. Students were unprepared for the muddiness of the unknown modelling environment and its explorative nature; “it was hard for me to identify the matrix categories”. Some students were at a total loss: “I didn't know what to do”. Here, Dewey (1938) distinguishes on the one hand, habit formation which invokes past activities similar to those in which current habits were formed. Accordingly, some students “failed to link this task with what I learned in class”. On the other hand, habit formation may “retain enough flexibility to re-adapt themselves to new conditions” (Dewey, 1938, p. 39). This flexibility empowered other students to adapt as they made connections with their familiar environment; “this task was about things that we see around us daily”. Dewey (1938) warns that habits bred in environments where conditions remain uniform, are “limited in their manifestation to the rather artificial conditions in which they operate” (p. 33). Such narrow habits can restrict students' adaptability to the modelling environment when they search for habitual confirmation of answers, “I will not know which answers are correct or wrong”. Conversely, an adapted mannerism is operationalised with the realisation that modelling “is an open-minded problem and every idea can be correct if it's thought through”.

4.2.3. Component 3 – Affiliation

Mathematical modelling tasks were done in small groups due to the complexity and richness of tasks (Biccard & Wessels, 2015). In the sense of Bourdieu's habitus, group work represents *social capital* within a mathematical modelling environment as microcosm of *field*. Acquired characteristics, values, preferences, behaviours and dispositions all contribute to *cultural capital* (Czerniewicz & Brown, 2013). Students realised the strangeness of the first task and re-strategised. “We came with different approaches” indicate to students' productiveness and receptiveness to adapt to a new environment. There was a willingness to embrace new ideas as students “learn more things from one another”. In recognition of social capital, one student confessed “the group opened my eyes”. Habitus however demands that new insights should drive future behaviours that surpass the status quo (Reay, 2004). “It made me open up and made me really inquisitive about things I've never met”. The social context in

which students were operating and “challenging” demands of the modelling tasks, imposed a modification of dispositions, without which the task “would have been a nightmare”. Certain dispositions were influenced by the field – the modelling environment – as students decidedly “combine ideas and come with something strong”. Due to group affiliations, students were stimulated by new learning experiences – “I can learn a lot from my peers” which also clarified some misunderstandings – “my wrongs were corrected”. Ultimately, students’ habitus is manifested only when they embrace attained social and cultural capital in successive events (Cutchin et al., 2008).

4.2.4. Component 4 – Aspiration

Habitus claims that the accumulation of social and cultural capital as experienced in the field also extends to how these resources are objectively nurtured and how it contributes to practices (Cutchin et al., 2008). In the case of the modelling environment, its contribution to generate habitus was weighed against students’ aspirations and expectations. New challenges – “I was determined to solve the task” – affirmed new dispositions in order to live up to expectations. But expectations as demanded from the field, can become a personal aspiration: “I should be able to convert the article from real world to matrices”. Habitus frames students’ appreciation of new experiences; “such approach should be done frequently in order to think open-minded”. Bourdieu asserts that practice, as the combination of capital and field, is manifested in the habitus of students when potentialities are recognised: “This [modelling task] can help greatly in other fields”. For students, practice must be tangible. “If it’s practical, it helps [me] understand in depth so that you do not forget”. Habitus is expounded in students’ career aspirations (Quaye, 2014). “A biomedical technologist needs to analyse on a daily basis” is a personification of new needs that must first be realised in order to achieve a higher goal – aptly a Figure 2d-quadrant 1 candidate. However, there is a conundrum here which points to a Figure 2d-quadrant 4 candidate: “You have to think out of the box but that cannot help me during the test or exam”. Habitus limits students to perceptions and appreciations as prescribed by practices (Cutchin et al., 2008). If mathematical modelling tasks are not formally assessed, students can argue that it should therefore not be important enough to transform their habits in order to still achieve their higher goals. This duality creates a state of counter-productiveness to habitus since “having a habitus that foresees success in a career in one’s future is clearly influential on one’s grades” (Dumais, 2002, p. 55).

6. CONCLUSION

PCA is a useful analytical method for quantifying and visualising dispositions towards mathematical modelling. As such, this method can guide the design of modelling materials and identify the load-structure of underlying latent constructs. Two non-procedural modelling processes – modification and exploration – correlated modestly with students’ affiliation towards group activities. An increased consciousness of the power of discovery awakened new desires; this demonstrates a receptiveness to transform habits. In turn, habit transformation formed the basis for students’ evolving habitus, actualised by the exigencies of a new environment (Dewey, 1938). For some, historical dispositions, so deeply rooted in old-school routines, are still firmly locked in a state of inertia. Isolated modelling tasks, infused into a traditional curriculum, could *mobilise* habit transformation, at most. Resolves from other constituent role players are much needed. After all, “we live and act in connection with the existing environment, not in connection with isolated objects, even though a singular thing may be crucially significant in deciding how to respond to total environment” (Dewey, 1938, p. 68).

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APPENDIX A: NEWSPAPER ARTICLE FOR 'MOOLAS FOR TRASH' TASK

Moolas for trash

Jbay Recycling Programme

A R70 000 donation towards 'Turning Trash into Treasure' reaches over 3000 community children who learn about the value of recycling, saving and the value of trading.

The Jbay Recycling Project, a community programme situated in Pellsrus, received a R70 000 donation from the Jeffreys Bay Wind Farm. The project was established in January 2011 and assists school-aged children to provide for their basic needs by exchanging recyclable materials like glass, paper, plastic and metal for items like toiletries, food, stationery, school uniforms, clothes and toys in a 'swop shop'. Aptly called 'turning trash into treasure', over 3,000 black children have participated and more than 250 tonnes of recyclable material has been collected since the Project's inception.

The project is operated from the community centre in Sarah Baartman Avenue, Pellsrus and serves children of Jeffreys Bay aged between 5 and 16 years. The best part is that all children are welcome and they get to choose their own goods, as adults are not permitted into the shop!

This unique community programme teaches children a number of essential values about the worth of recyclable goods, saving their Moola's, trading, independence and self worth



<http://jeffreysbaywindfarm.co.za/community-projects/jbay-recycling-programme/>

APPENDIX B: OPEN-ENDED QUESTIONNAIRE

1. Was this problem easy or hard for you to solve? Why do you say so?
2. What part of the task was the hardest for you?
3. Did this problem help you to apply your knowledge of the straight line to other contexts? Why?
4. Did this problem help you to realise the usefulness of the straight line in real life?
5. Did you enjoy doing this problem or do you prefer the traditional theoretical straight line problems?
6. Were you more motivated doing this problem as a team than if you had to do it by yourself?
7. Would you have preferred to rather work alone?
8. Do you think you would have been able to solve this problem all by yourself? Why?
9. What was your general experience today about working in a team?
10. How would you describe your own involvement in the task?
11. Would you like to see more of this type of real life problems in the syllabus or do you prefer to do Mathematics in the strict theoretical sense? Why?
12. Do you think this approach to do Mathematics can help you understand things better? Why?
13. Do you think this approach can be useful when you need to use Mathematics in your other subjects?
14. Give any comments you may have about your experiences today.