Pythagoras - Journal of the Association for Mathematics Education of South Africa
ISSN: (Online) 2223-7895, (Print) 1012-2346

Pre-service mathematics teachers' perceptions based on two differing mathematically underpinned debates

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Dates:
Received: 11 Oct. 2023
Accepted: 10 July 2024
Published: 16 Sept. 2024

How to cite this article:
Cornelissen, B., & Julie, C. (2024). Pre-service mathematics teachers' perceptions based on two differing mathematically underpinned debates. *Pythagoras, 45*(1), a789. https://doi.org/10.4102/pythagoras.v45i1.789

This study explores how pre-service mathematics teachers build alternative model simulations of real-world scenarios. Inclusion in the formal structures for wealth generation and accumulation is a fervently debated issue in South Africa. Share owning in companies listed on the Johannesburg Stock Exchange (JSE) in South Africa is one of many wealth-building tools. Related discussions evolved on the spread of share ownership among black and white citizens. Two mathematically motivated positions were reported in a newspaper. In one of their mathematics courses, prospective mathematics teachers were presented with the article and asked to reflect on it with the prompt 'Which of these two methods for determining the "number of Black South Africans holding shares on the JSE" would your group support?' Audio- and video-recorded data were collected and subjected to thematic analysis. The themes that emerged from the analysis were economic empowerment, authority of research and trustworthiness of information. The discussions reflected on the complexities and rationalities involved in decision-making of mathematically driven opposing positions on issues of social importance. The mathematically derived results of such issues will eventually be resolved in the political field. The findings revealed that building of alternative mathematical models by pre-service mathematics teachers begins with an explicit problem setting, followed by the development of mathematical models that included real-world problems.

Contribution: This article contributes to pre-service mathematics teacher education by exploring how such teachers deal with the issue of critical engagement of mathematically based arguments, highlighted in the Curriculum Assessment and Policy Standards (CAPS) document for school mathematics.

Keywords: authority of research; trustworthiness of information; economic empowerment; mathematics; teachers; perceptions.

Introduction

In 1998, South Africa's then-deputy president referred to the South African population as bipartite, with one half white and rich people and the other mostly black and impoverished people (Mbeki, 1998). The governing party's pledge to work for opportunity for all citizens to benefit from the country's wealth is one of the apices to address the disparate distribution of affluence in South Africa (African National Congress, 1994). Black Economic Empowerment (BEE) was seen as a way to achieve this. According to Ponte et al. (2007), one of the critiques of BEE was that only a privileged few black people benefitted through the awarding of shares in white-owned companies. The dissatisfaction with BEE and its various versions such as Broad-Based Black Economic Empowerment spearheads the urge of certain political and civil society formations for radical economic transformation. The research reported was conducted in this context.

The aim of the research was to unravel prospective Mathematics teachers' engagement with issues related to BEE as it pertains to shareholding on the Johannesburg Stock Exchange (JSE).

This is followed by the conceptual orientation of study. The subsequent sections deal with data collection, data analysis and the findings of the study. The article ends with a brief discussion of the findings against the conceptual orientation and a consideration of the complexity of mathematically modelling shares on a stock exchange.

Research methods and design

Schooling and economic development

Among the variety of aims for schooling, one is the preparation of learners to participate in the economic activities of their countries after graduating from school if they do not continue to some

form of post-school education. This economic ideal contribution is also implicitly contained in the various definitions of citizens as economically productive members of society. An expected attribute of school graduates is that they will somewhat seamlessly transition to the world of work and their achievement scores will provide business owners with an indication of their capabilities of readiness for the world of work. The readiness competencies are recently propounded as those necessary for economic growth related to the knowledge economy and the Fourth Industrial Revolution. Mathematics, together with numeracy, as part of the Science, Technology, Engineering, and Mathematics (STEM) configuration is identified as crucial for the development of the desired competencies for economic growth in the 21st century (Jazby 2017; Sahlberg 2006; Valero 2018).

The aforementioned ideas in the literature deal with citizens participating with school-acquired competencies to productively contribute towards their country's economic growth. Being employed can contribute to an individual's accumulation of personal wealth through savings and investing in other financial investment schemes. Of these 'other financial investment schemes', investing in stock markets is the focus of this article.

Early work on engaging learners with stock markets was done by Schultz (1957) and Scott (1957). In these two publications, learners had the opportunity to practise a variety of elementary mathematical skills, as well as following the performance of fictitious investments in a stock market to gain insights into how the stock market works. Both these publications, in addition to engaging learners in practising a variety of elementary mathematical skills, also afforded learners the opportunity to follow the performance of imaginary investments on a stock market to gain insight on how the stock markets operate. Kaiser and Schwarz (2006) also report on how high school students who were motivated by the stock market boom chose to engage in the stock market in a full-fledged, self-selected mathematical modelling project. They observe that 'it became quite clear that the students' high-pitched aims and expectations to develop a model to predict share prices was less realistic because such a model would lead to a collapse of all stock markets' (p. 205). Despite this observation, one of their results was that it is possible to allow high school students to engage in intricate mathematical modelling activities such as trading on the stock exchange.

Studies conducted on this topic in South Africa include pre-service mathematics teachers' knowledge of compound interest and annuities (Pournara, 2013, 2015), effectiveness of a group teaching approach on achievement in financial mathematics constructs such as hire purchase, inflation, exchange rates, simple and compound interest (Dhlamini & Mogari, 2013), university teachers' perspectives on cultural aspects influencing learners' handling of tasks in financial mathematics (Makonye, 2020), and difficulties learners experience with financial mathematics due to the language of instruction (Bayaga et al., 2021). Overall, these studies highlight the problems being experienced with issues related to Financial Mathematics.

Shares, shareholding and stock exchanges is not a topic in the South African school Mathematics curriculum. The Accountancy curriculum of the last three years of non-compulsory schooling (DBE, 2011) in South Africa include the topics shares, shareholding and stock exchanges. Accountancy is a non-compulsory subject and most learners who select it as a subject also take Mathematics.

The above literature indicates that there is a paucity of, if any, research on how prospective Mathematics teachers respond to different mathematically underpinned research outcomes on shareholding on a stock exchange. The specific research question pursued was: 'What issues drive pre-service teachers' discussions when they engage with different mathematically underpinned conclusions regarding shareholding on a stock exchange as a form of economic inclusion?'

Conceptual orientation

Broadly viewed, this study is situated in the applications of mathematics. Applications of mathematics is viewed in the sense offered by Blum and Niss (1991, p. 40) as 'every piece of mathematics which in some way is or may be related to the real world can be seen as belonging to applied mathematics'. Skovsmose's (1992) notion of the need of metaknowledge to engage with and appraise the applications of mathematics also forms of part of conceptual machinery. In particular, for the reflections on the pre-service teachers' deliberations, Skovsmose and Yasukawa (2004) propose three questions for deliberations on the applications of mathematics. They view the outcomes of the applications of mathematics as part of a mathematical model, which they label a 'package'. The three questions are 'What is in the package?', 'Whose package is it?' and 'What could be done by means of the package?' (Skovsmose & Yasukawa 2004). These questions are components of the needed metaknowledge proposed by Skovsmose.

Data collection

The context of the data was a seminar-cum-workshop on mathematical models and the applications of mathematics offered to pre-service mathematics teachers. Twenty-four pre-service mathematics teachers (14 female and 10 male) in their final year of study of their four-year programme participated. Issues addressed included, among others, a discussion of the diagrammatic representations of modelling presented by Stillman (1998) and Blum and Leiβ (2007), mathematical competencies, and critical discussion of mathematical models through awareness-building that different models can represent the same phenomena. After each presentation of an issue, the students were given a task related to the presented topic to work on. The students work in self-selected groups of not more than four. Figure 1 illustrates the type of questions set in the National Senior Certificate, Grade 12 final examination on Financial Mathematics.

The task related to this article was the first task and is given in Figure 2.

Two friends, Kuda and Thabo, each want to invest R5 000 for four years. Kuda invests his money in an account that pays 8.3% per annum. At the end of the four years, he will receive a bonus of exactly 4% of the accumulated amount.

Thabo invests his money in an account that pays interest at 8.1% p.a., compounded monthly.

Whose investment will yield a better return at the end of four years? Justify your answer with appropriate calculations.

Source: Department of Basic Education. (2019). *Grade 12 Mathematics Examination Paper*. Pretoria: National Examination Board.

p.a., per annum.

FIGURE 1: Financial Mathematics question in 2019 NSC Mathematics examination.

Read the attached article and discuss in your groups:

Which of the two methods for determining the "number of Black South Africans holding shares on the JSE" would your group support?

Choose a spokesperson to present, with reasons, for your choice.

JSE, Johannesburg Stock Exchange.

FIGURE 2: Task for the shareholding activity.

The article was on shareholding. It appeared in the business section of a Sunday newspaper. The essence of the article is captured in the caption of an image of the JSE and it reads 'Do the math: For the first time, according to Alternative Prosperity (AP)'s research, the number of black South African holding shares in on the JSE had overtaken the number of white shareholders' (Greenblo, 2015). The article compares the conclusions reached by AP and those by the National Empowerment Fund (NEF).

The article deals with BEE and reports the percentage ownership held by black shareholders in the top 100 companies listed on the JSE.

Overall, the article reported that according to the AP study black people own 23% of the shares of the 100 companies. The NEF study concluded that black people own 6% of the shares.

The reported results are given in Table 1. At a surface level the applications of mathematics comprised applying percentages to numerical data mined from various sources.

Other than in the caption, no further reference is made to white shareholders.

The second author did the presentations. The data sources were audio- and video-recordings of the engagements of the groups with the activity, video-recordings of the report session and observation notes kept by the first author who also transcribed the data and led the analysis which is described in the next section.

Data analysis

The data were subjected to thematic analysis following the well-rehearsed six-step procedure of data familiarisation, initial code generation, identification of themes, revision of themes, definition of themes and the writing up process (Braun & Clarke, 2006). The first author started by reading through all the transcripts to get a first impression. Thereafter,

TABLE 1: Percentage BEE shareholding according to AP and NEF.

Description	AP study finding, based on JSE†	NEF study finding based, restated to be based on JSE†	AP finding, based on local operations	NEF finding, restated to be based on local operations
Conclusion reached on direct BEE (%)	10	6	17	10
Conclusion reached on indirect BEE (%)‡	13	Not applicable	22	Not applicable

Source: Greenblo, A. (2015, May 31). How many top 100 companies are Black? *Sunday Times (Business Times)*, p. 12.

AP, Alternative Prosperity; NEF, National Empowerment Fund; BEE, Black Economic Empowerment; JSE, Johannesburg Stock Exchange.

†, This figure is based on the shareholder weighted index (SWIX); ‡, BEE legislation specifically allows for either the inclusion of mandated investments in BEE calculations or its exclusion from both the numerator and the denominator of the calculation.

TABLE 2: Themes and related codes.

Themes	Economic empowerment	The authority of research	Trustworthiness of information
Codes	• Privileged few	• Neutrality	• Bias
	• Black Economic Empowerment	• Interests	• Fairness
	• Black ownership	• Competence	• Trust

the initial impressions were noted down and the transcripts were re-read to further acquaint herself with the data. The audio and video transcriptions were checked against the original recordings and mistakes were corrected.

Atlas.ti (version 8), the qualitative data analysis software program, was used for code identification and naming. The initial codes were grouped to generate initial themes. These themes and accompanying codes with the data slices were re-read, constantly using the entire data corpus to check the viability of the themes to arrive at the definition of the themes. An iterative process of prolonged data immersion and reflection (Braun & Clarke, 2019) was thus followed to generate themes for further verification by others.

For the verification of the initial analysis, the data and outcomes of the analysis of the first author were presented to the second author for verification. He considered the outcome of the first analysis independently, raising questions and disagreements with the first author's data analysis. Both authors reached consensus after this process.

Additionally, extracts from original transcripts were given to three independent knowledgeable researchers to examine if they agreed or disagreed with the codes and themes that were identified. They had to score their outcome on a three-point scale (1 = agree; 2 = maybe; 3 = disagree). The scores were tallied and the majority outcome was taken as verification for the derived themes of the authors. No disagreements arose. The results that emerged are presented in the next section.

Ethical considerations

Ethical clearance to conduct this study was obtained from the University of the Western Cape, Humanities and Social Science Research Ethics Committee (No. HS17/10/31). Participation was voluntary and students signed a consent letter prior to data collection.

Results

Table 2 is a summary table of the themes and their originating codes.

The individual themes are elaborated below with examples of the utterances of the participants. In the description that follows, M1Gr1 refers to Male 1 of Group 1, F1Gr1 to Female 1 of Group 1 and so forth.

Economic empowerment

Generally, the discussions kept closely to the article the participants had at their disposal. The codes are thus more of an in-vivo type. The aspirant teachers referred to aspects such as 'privileged few', 'BEE', 'black ownership' and 'King III Report'. The King Committee on Corporate Governance issued four reports, namely King I (1994), King II (2002), King III (2009) and King IV (2019). The King IV Report on Corporate Governance is a booklet of guidelines for the governance structures and operations of companies in South Africa. The intention of the King IV report is to broaden acceptance of corporate governance by simplifying and defining governance objectives. Compliance with the King Reports is a requirement for companies listed on the JSE (*Companies Act*, 2008).

During the report-back by M1Gr1, he placed the emphasis on the 'privileged few' by saying:

> 'So, with the National Empowerment Fund (NEF), we found it highlights only a privileged few shareholders. So, it doesn't take everyone into account. Obviously, shares must be directly held by black individuals. And those are the only ones that they referred to in their results.' (M1Gr1)

The reference to 'privileged few' is ostensibly also drawn from current political discussions on distribution of wealth in the country which is linked to economic empowerment. This discussion revolved, from both the governing party and opposition ones, around how only a narrow stratum of previously disadvantaged groups benefitted from BEE.

The participating prospective teachers also focused on 'BEE' for arriving at their choice of the AP position over the NEF one. In an exchange one participant uttered, 'The NEF don't account for everyone' (F2G3) with another one supporting her by saying, 'Yes. They don't even follow the BEE criteria' (F1Gr3). Another group was more explicit on how BEE drove their choice. Regarding this, F3Gr1 rendered the group's choice, based on BEE considerations, as:

> 'Our group chose the Alternative Prosperity group. … We also said that they are consistent with the BEE. … This group also includes annual reports and financial statements which means that they have a variety of information sources, which include the share registers of JSE-listed companies, BEE certificates of these companies.' (F3Gr1)

The BEE deliberations brought into the discussion the distribution of ownership shares. The concentration of the discussions was on the nature of the ownership by direct and indirect ownership of shares. Although support was expressed for AP's findings that their 'results actually show a positive increase in the amount of people – the amount of black ownership in the business sector and the companies listed on the JSE' (M1Gr3), there was realisation that this ownership includes indirect ownership. This was stated as 'the white people would use, they will do part of the JSE companies and they do it throughout the years but whereas the black people are like on pension and then they invest in the JSE' (F3Gr2) highlighting that white and black people hold different kinds of ownerships: the former group holds direct while the latter holds indirect ownership. This accounts for the conclusion:

> '[*B*]lack ownership on the JSE stood at only 3% (M1G1) and 30% of white owner – that leaves like 60 something percent that are then not you know captured. But they're shares so they must be there somewhere.' (M2Gr3)

The authority of research

This theme encapsulates compliance or not with accepted procedures of research conducted by the two bodies who reached different conclusions. Most of the participating groups referred to the AP group as being unbiased while the NEF was deemed to have vested interest. Three codes comprised this theme. They are neutrality, interests and competence.

Neutrality was associated with independence of the AP research group. F1Gr2 stated the link as:

> 'So we know this [*Alternative Prosperity*] is independent research that was done, so independent research according to me is based on like, you must be neutral, like it's your being because it's an independent thing, you come in and you do basic research.' (F1Gr2)

The impartiality of AP was also questioned:

> '[*T*]he only, the one negative with AP though is that if it's commissioned by JSE, JSE, not to say they manipulate but obviously, they're going to try and get the best-looking results coming out of it.' (M1Gr3)

The independence of AP was contrasted to the NEF, deemed to not be impartial, through:

> '[*I*]t [*the NEF*] cannot be considered independent because it's a creature of government, so a creature of the government, then they would report, to our experience, to the president.' (F1Gr1)

The code of interest is closely linked with neutrality but has more to do with the explicitness with which the former figured into the deliberations of the participants. As already indicated above, the impartiality of the NEF was questioned. This questioning revolved its research having been commissioned and 'being funded by the JSE' (M1Gr1) and the company wanting to produce the 'best-looking results' (M1Gr3) for the JSE:

> 'He was responsible; he was responsible to Zuma, yes.' (M2Gr1)

'Zuma is the one who is the championing this information over the Alternative Prosperity one.' (M3Gr1)

'So it's linked to Zuma.' (F1Gr3)

F1Gr3 indicated the explicitness of 'interest' of the NEF expressed by the cohort of pre-service teachers. In doing this, vested interest was directly assigned to the serving president of South Africa at the time.

The above paragraphs show that the cohort was aware that neutrality and disinterest could be difficult for research groups to adhere to.

Competence refers to the resources consulted and used to construct the model. This was articulated as:

'Yes, it might be imperfections, but it just seems more realistic considering they take a more holistic kind of approach to it.' (M1Gr3)

'Holistic kind of approach' is a collective term for 'including share registers of JSE-listed companies, BEE certificates of these companies or their unlisted South African subsidiaries, annual reports and financial statements, and data directly obtained from mandated investors' (Greenblo, 2015). Comparatively, the NEF was deemed less competent compared to AP:

'[*T*]hey even included the BEE thingy, certificates and stuff which is which is something the NEF didn't do.' (F1Gr1)

Trustworthiness of information

Trustworthiness denotes the extent to which information was deemed sufficiently reliable for inclusion in the pre-service mathematics teachers' decision-making. The three codes in this theme are bias, fairness and trust. They deal with the focus of the research and refer to the confidence in how well the data address the intended focus (Polit & Beck, 2012).

Bias figured strongly in the discussions and was generally attached to the NEF's research:

'But I feel like the NEF, it's kind of like bias.' (F1Gr1)

'I feel the NEF is bias because maybe it is not going to expose the bad side of all the companies.' (F2Gr1)

When the AP's research was alluded as also being biased through:

'It is biased because by president JSE you know.' (F4Gr2)

It was summarily countered by:

'[*T*]he JSE can't be bias[*ed*].' (F1Gr2)

Fairness had to do with inclusivity of the apartheid-defined racial groups (African, mixed race, Indian and white). Black is normally used as the collective term for the first three groups. However, black is also used to refer only to Africans. During the report-back, it became clear that the students had the notion that black refers to Africans only and the presenter had to intervene to remind the students that black South African includes the groups as in the aforementioned explanation about the racial classification system in use in the country. The following are excerpts of discussions related to fairness:

'It wouldn't be you know fair to take the NEF because they don't account for everybody.' (F2Gr3)

'So, we have to decide which one was the best, which one is the fairest, I think because now they saying it was AP here, the Alternative Prosperity.' (F6Gr2)

'We are choosing the AP approach. Why? Because they make it more multicultural and it is broader.' (F3Gr2)

Overall, the NEF was deemed as not being fair while AP was viewed as, at least, being fairer because of the inclusivity of the entire racial composition of South African society.

Trust is generally linked to bias but also has to do with the believability of information the cohort had at hand. Doubt was expressed regarding plausibility of the data provided by the NEF as forthcoming for the discussion excerpt below:

F2Gr2: Here they're saying, the only guess 23% of the JSE's top 100 listed companies, almost close to 30 whereas the NEF saying they only own 3%.

F6Gr2: 3%.

F1Gr2: So I don't understand that why they are giving us that information?

F3Gr2: I don't know how to do that to be honest. Only what they [*the NEF*] want.

Contrasting the NEF with the JSE, the former was considered to be manipulating figures and predisposed to 'state that there are low percentages. … But the thing is the JSE has no reason to lie' (M1Gr1).

The above shows that a higher degree of believability was expressed for the information of AP than for that of the NEF.

Conclusion

Pre-service teachers' responses to a mathematically driven article in a newspaper were pursued. The content of the article was the participation of black South Africans in the 100 largest companies listed on the JSE. Different results were obtained from applications of mathematics implementations by two different research institutions. Future teachers discussed the article.

The analysis shows that aspects of the applications of the mathematics process were virtually ignored. Shareholding is a double-edged instrument for wealth creation. It has boom periods but is also prone to stock market crashes and 'historical (backward-looking) returns do not necessarily predict future returns' (Van Appel & Maré, 2022, p. 1). The mathematics involved in the ebb and flow of investment returns of companies listed on a stock exchange is complex. A country's citizens normally get some surface level sense of

the mathematical dimensions of the ebbs and flows through the print and digital media. It is thus not reasonable to expect that ordinary citizens would engage with investments in companies by considering and questioning the intricate mathematical underpinnings driving decision-making regarding investments in companies listed on a stock exchange.

Another issue emerging from the analysis is that there was a focus on the credibility of the research entities the reporter of the article used in his argument. This is linked to Skovsmose's (1992) metaknowledge and the three questions of Skovsmose and Yasukawa (2004). The themes forthcoming from the analysis indicate that the prospective teachers engaged primarily with 'Whose package is it?' with some attention accorded to 'What is in the package?' This they did without their attention having been drawn to these questions during the lecture component of the workshop. This raises the question on whether at a broader level citizens in their deliberations on competing mathematically driven arguments on a particular social issue of import will implicitly be driven especially by 'Whose package is it?' We venture to guardedly respond to this question in the positive because ultimately the resolution of an issue with a strong ideological dimension, such as equitable distribution of shareholding by race in a country with one of the highest Gini coefficients, will be won in the political arena and rarely through who did the better application of mathematics.

Acknowledgements

Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

B.C. is the first author; C.M.J., the co-author, is aware of the manuscript's submission and approved the final version.

Funding information

This research is supported by the National Research Foundation (NRF) of South Africa under grant number 77941. Any opinions, findings and conclusions or recommendations expressed in this article are those of the author and do not necessarily reflect the views of the NRF.

Data availability

The data used to support the findings of this study are included within the article.

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