Calculating Pascal's Principle in a Non-Hearing Grade 9 Technology Classroom

How Do Deaf Learners use Sign Language to Enhance Calculation in Hydraulics

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***Abstract*—Education is a constitutional right of all children granted to improve the quality of life for all citizen and the condition under which they live, prioritising Technology and scientific subjects for Technology literacy through English as a medium of instruction. Deaf learners engaged with these subject through Sign Language that has not been officiated for mediating learning in education. This paper aims at understanding the comprehension of concept formulation and breakdown in Deaf learners when they engage with hydraulic systems' calculation if properties in concept formulation follow Mathematics procedure for numbers. Moreover it explored the utilization of Sign Language to enhance calculations in hydraulic system. This study is guided by constructivism and social constructivism theory as participants were building on their knowledge and experiences as well as interactive learning for effective learning. This was a case study since the research was done in one grade 9 Technology classroom where five Deaf learners where purposely chosen in the enquiry. Participant observation, document analyses and interviews were used within the qualitative mean to develop and analyse data that aided the researcher to comprehend the perspectives held by participants. Participants had good retention ability to concepts they engaged with through Sign Language. When tasks involve single stimulus, participants were able to recall related aspects. Lastly participant encountered challenges on tasks that depended on integrated knowledge from multi-dimensional. Participants should engage actively.**

Keywords— Sign Language; Deaf learners; Mechanical Systems; Pascal's principle; nterdisciplinary

I. INTRODUCTION

Education has been considered a constitutional right for all children in the General Education and Training (GET) band in South Africa, placing a priority on Science, Mathematics and Technology (SMT). Technology concepts considers laws that express physical phenomena through scientific observation and experimentation consolidated into description thereafter. Concepts are identified and categorized based on experiences produced by experimentations that underline the physical properties. A lesson in Technology may start by simulations, observations, demonstrations and/or precise description of concepts or activities but the brain revolve to the point where learners recognize the concept immediately. Describing the process in the concept formulation is not the key issue in Technology but the comprehension of the breakdown of the concept and the internalization of the descriptive process into basic properties give the reason for considering that particular concept in Technology design. Properties in concept formulation follow Mathematics procedure through binary operations and yield to the same rules as the corresponding Mathematics operations for pure numbers. For example, the concept of pressure in Technology is learned through the application of Pascal's law. The learning process is mediated through English as a medium of instruction but uses Mathematics language for procedural proficiency.

Within the democratic right of education and the inclusive nature of Technology, Deaf learners are using Sign Language to translate the meaning of Technology concepts that are learned through verbal language. Within the 11 languages that were accorded the status of official language by the language policy in the democratic era in South Africa, Sign Language still endures language inequality as it is not officiated for administrative and education mediation, yet used for mediation in Deaf schools for more than 24 years. A challenge is that Sign Language remain at the periphery of the formal translation in South Africa as English is at the centre of education and technological sector of the country. Deaf learners are at the disadvantage state of language accusation as language is factored into the literature relating to the academic programs of the school curriculum. This paper has identified the calculations of hydraulics as an interesting context in which to explore the use of Sign Language by Deaf Leaners. A research question remains as how do Deaf learners use Sign Language to enhance the comprehension of calculations on hydraulics?

This study was guided by social constructivism through blended learning. Social constructivism is a way in which facts of life are analysed in order to predict knowledge relationship found in human development through interaction between individuals. In Mace [1]. Social constructivism theory believe that people are responsible for social structures and their conditions through language. Social constructivism is foregrounded on Vygotsky's work that emphasises a good learning rooted on social interaction as a fundamental role of cognitive development. Technology is a learning area that integrates theory and practice and involves the application of concepts of different sciences that inform adequate technological designs. This paper encompasses the notion of blended learning, as a strategic approach to learning that integrates the best aspects of theoretical learning and practical application through Mathematics language and Sign Language engagement Djenic, Krneta, & Mitic [2]. Blended learning was used to look at how Deaf learners develop the practical insight required for calculating pressure using the concepts of Pascal's principles embedded in the study of hydraulics systems.

Adequate application of Mathematics concepts in the calculations of pressure within a bounded system using Pascal's principle will be a typical example of transformative learning that depicts comprehension of hydraulics as a *Tacit knowledge in* Deaf learners. *Tacit knowledge* is an evidence of skills gained through experience after an intensive practice. It is communicated through a 'watching and doing' form of learning. It entails skill formation through demonstration and modelling and is related to how an individual interprets learning in the form of intimate interpersonal learning experiences. As an aspect of social constructivism, Sign Language was an instrument of communication used to mediate learning in the non-hearing classroom. Transformative learning is what enables learners to apply what they have learnt to a new situation. It brings about a personality change that has an influence on learners' purposive learning, projection and practice in the context of hydraulics systems Illeris [3]. Blended learning organises the knowledge structures essential for using related concepts in analysing design through critical thinking.

II. REVIEW OF LITERATURE

A. *Hydraulics and its place in the school curriculum*

According to Paul [4], Hydraulics is the study of physical behavior of all fluids in motion and at rest. The consideration of all fluids emanated from water analysis as a natural resource and hypotheses were extended to other fluids in consideration to their viscosity. Hydraulics systems are therefore adopted in the quest for "how force can be transmitted to another unit using fluids"? Pascal's principle is adopted for hydraulic systems to adhere to the law of simple machine. The application of these hypotheses to human needs enhance Technology literacy to learners.

Technology is a school subject adopted to enhance knowledge and skills to all learners in the GET band inclusively. Technology embrace the significance of using natural resources when addressing societal needs. It is guided by Technology CAPS document to link policies and practice that promote academic and practical values for Technology literacy on learners for design skills in the classroom. The Technology CAPS document catered for learner-centeredness where learners are involved in action research through the observation of specific phenomena. It also advocates for a capability task where learners are expected to combine knowledge and skills into a working project. The focus is on developing practical solution to existing problems, with a high consideration of social and environmental factors. Hence water is used in hydraulics systems lessons to discuss Pascal's principles. The functionality of Pascal's principle is rooted in the inderdisciplinarity of Technology with other sciences and Mathematics. In Brijlall & Thabethe [5]. Inetrdisciplinarity in Technology means, the enhanced knowledge from borrowed vocabulary, principles of natural behaviour in natural resources/commodities and mathematical standards that provides procedural knowledge.

B. *Language significance in Technology*

Language has a complex role in Technology in the sense that proficiency in language enable learners to migrate between the language of instruction and the specialised vocabulary used in Technology. Sometimes the learning process is mediated through a different language of instruction as compared to the language of communication. This creates a huge challenge to learners to translate the content language for understanding without losing the meaning. Technology capitalises on characteristics of natural resources drawn from scientific findings and use them to address human needs. For example, when air is confined to the limited space, air is compressible but when water is confined to a limited space, it cannot be compressible. Furthermore to that, pressure is equal at any point within the limited space. The discovery of such fundamental laws is represented using a specialised language and such representations are referred to as formulas denoted by pressure e.g. Pressure = force divided by area

$$(P = F/A).$$

The specialised vocabulary used in Technology is qualified through Mathematics discourse where Mathematics vocabulary, specialised syntax and Mathematics symbols are used to justify the special way of thinking evident in written and spoken form of Mathematics.

C. *The implication of Mathematics to hydraulics systems*

Mathematics is a language that deals with specialised systems [6](Ruelle, 2007). In technological process for Pascal's principle, the guiding principle in the design of "simple" machine is regulated by the law of simple machine in highlighting that work-done at the input side is equals to the work-done at the output side e.g.

$$(W_{in} = W_{out}).$$

This is apparent in the hydraulics system where

$$P_{in} = P_{out} \approx F_{in}/A_{in} = F_{out}/A_{out}$$

where F is force applied and A is a surface area covered. Mathematics use formulas as sentences, symbols and alphabets and binary operations as conjunctions. In this context, a typical algebraic problem compels the solving of equation

$$(F_{in}/ A_{in} =F_{out}/A_{out})$$

by substituting terms, observing general behaviour and patterns of sets of numbers and variables with their operations. Mathematics has a practical value and instructional use that may only be expressed in numbers Dautray & Lions [7]. Technology is complementary to Mathematics in that Mathematics principles justify quantities in the form of arithmetic notation. It is aimed at providing proofs of logical arguments in Technology activities. Devlin [8], viewed numerical science informs the science of abstract patterns, abstract shapes, and patterns of motions that are visual, imaginary or mental/verbally and numerically. According to Devlin [9] it is the invention of numbers and arithmetic notation that provides proof of logical arguments in worldwide Technology activities. Formulas are used to interogate science of numbers, shapes and motion relating to algebra, arithmetic, geometry and trigonometry, where letters and symbols are dominant in the presentation of quantities of equations. Binary operations are used to craft the required meaning within the language of Mathematics. The table below illustrate the formation of binary operation algebraic sentences, grammar therein.

Table 1: Binary operation and mathematical application Modified from Morrison [10]

Binary operation	Mathematical symbol	Interpretation	Application
Plus	+	Three plus two equals five	3+2=5
Times	×	Three times two equals six	3×2=6
Minus	-	Three minus two equals one	3-2=1
Divided by	÷	Three divided by two	3÷2=11/2
Raze to the power	X^2	Three to the power two	3^2
Brackets	()	Three plus two	(3+2)=5 (3×2)=6 but(3+2)≠(3×2)

In that regard, Learners are expected to explore formulas by applying them to relevant solution-seeking calculations based on problem statements, graphical representations and/or diagrammatical representations Houston [11]. Technology embrace multilingual approach in the sense that language of instruction, Mathematics language and scientific terms are used simultaneously in problem solving. Multilingualism means the application of several languages by an individuals in their communication for diverse roles fluently Kumar & Singh [12]. Multilingualism in education is derived from different approaches to education participation through language aimed at supporting curriculum goals.

D. *Multilingual approach to the learning of hydraulics systems*

Multilingualism in hydraulics systems is derived from different approaches that include home language, language of instruction and Mathematics language aimed at supporting curriculum goals. Multilingualism commonly includes the mother tongue, English that is commonly used as a medium of instruction and Mathematics used as a universal language. According to Cenoz & Genesee [13] a multilingual approach to education is attributed to numerous factors that influence social interaction, e.g. linguistic heterogeneity for the country, specific social attitudes and a desire to promote identity. Although this study is not projected to language, it is paramount to consider it as an appropriate foreground for educational application and an essential social link. Effective learning encompasses social attitudes towards a particular language and practical use of that language, the purpose of using a particular language in a society and the relationship between language use and social factors. Multilingualism provides a positive effect in the understanding of concepts of Pascal's principle in hydraulics system. Multilingualism provides coherence between language of instruction, language used for social communications and a language related to Technology (Mathematics language). Moreover, it (multilingualism) lays a solid foundation for learning and application of Technology; it promotes literacy in Technology and enhances better communication in problem solving, improving outcomes and facilitating the learning of Technology by informing an understanding of instructional design. It ensures a multidimensional nature when a person is carrying out educational decisions. Clarkson & Galbraith [14] alluded to the fact that multilingualism has a significant influence on numerical science that is considered as a cornerstone of Technology applying related concepts in design. Integration of concepts in a multidimensional problem in Technology ensures a threshold of competency in technological design envisaged in Technology CAPS document. This ensures language appropriateness that extends to the cognitive level of learners and their social and emotional readiness to adapt to a range of skills, and aligns the abilities of a learner for prescriptive learning Gestwicki [15].

The application of hypotheses in hydraulics system is guided by the standardized process of mechanism as shown in

Figure 2.

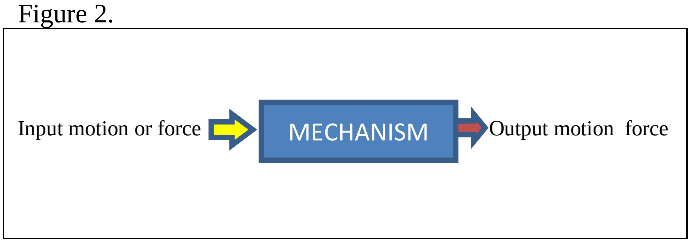

Figure 2: Process of mechanism

The process of mechanism is concerned about manipulating the applied force for a better resultant force through the use of the Law of Simple Machine ($W_{in} = W_{out}$). A comprehension of the Law of simple machine in conjunction with the knowledge of the process of mechanism enable learners to effectively engage with a systematic manipulation of

$$(W_{in} = W_{out})$$

that relate to

$$F_{in}/A_{in} = F_{out}/A_{out}$$

within a bounded system. Such formulas are easy to retain even when there are not explicitly written. A crafted formula has in principle an external memory of an object that can be useful in manipulation given information according to the well-defined rules Ruelle [16]. Furthermore, formulas can be represented without the use of natural language to denote structures created through society practices. This is an essential element of intellectual tool for critical and creative thinking envisaged by Technology CAPS curriculum in design (DoBE [17].

III. METHODOLOGY

The study was conducted in grade 9 Technology classroom where five Deaf learners where purposely chosen to participate in the enquiry. All participants were classmates for almost eight years. This was a case study since the research was done in a single sight. Stake [18] describes a case study as a strategic enquiry in a single case where a researcher explores in-depth programmes, events, activities, process and/or individuals. A case focusses on the knowledge that emanate from experiences and draw attention to the influence of its social context (Henning, Van Rensburg & Smit, [19]. The focus was on the application of Pascal's principle in hydraulic system through Sign Language since the mediation of all subjects was done through Sign Language.

Sign Language has been considered for facilitating learning in Deaf schools. Data collected in non-hearing environment depend on a unique vocabulary from a visual language and require a deeper description. For this reason qualitative approach was chosen to provide an understanding of the situation where hydraulic system was medicated through Sign Language (Cohen, Manion, & Morrison, [20]. Qualitative approach allows for the use of various research strategies for data collection that highlights perspectives of participants. This enquiry was done within an interpretive paradigm since the researchers provided a subjective understanding of Technology class in a non-hearing environment. The interpretive approach incorporate some research approaches that underline the true and the meaningful nature of participants in learning activities (Babbie, Mouton, Vorster, & Prozesky [21].

IV. RESEARCH INSTRUMENT

We identified three methods of data collection: participant observation, document analysis and interviews.

A. *Participant observation*

Participant observation is the qualitative means of data collection that depends on narratives. It is a qualitative method with roots in traditional ethnographic research, whose objective is to help researchers learn the perspectives held by study populations (Jorgensen [22]. This instrument works under the presumption that there are multiple perspectives within any given community and we were interested in knowing what those diverse perspectives are as well as understanding the interplay among them.

B. *Document analysis*

Our focus was on how participants responded to the hydraulics jack problem. It is through their individual responses to this question that we could verify adequate application of knowledge rooted in the interdisciplinarity of hydraulic system and Mathematics. We verified as well that this exercise is guided by the prescripts of Technology CAPS document.

C. *Interview*

Unstructured interviews were used to scrutinise individual responses in different steps of participants. Cohen et al. [23] contend that the "interview provides access to what is inside a person's head which makes it possible to measure the knowledge or information, value and preferences as well as attitudes and beliefs". Interviews assisted researchers to corroborate findings from observation and document analysis (Brijlall and Thabethe [24].

V. RESULTS

In their cognitive process, participants were able to provide signage of the following terms used in calculating 'hydraulics in Pascal's principles

A. *Force*

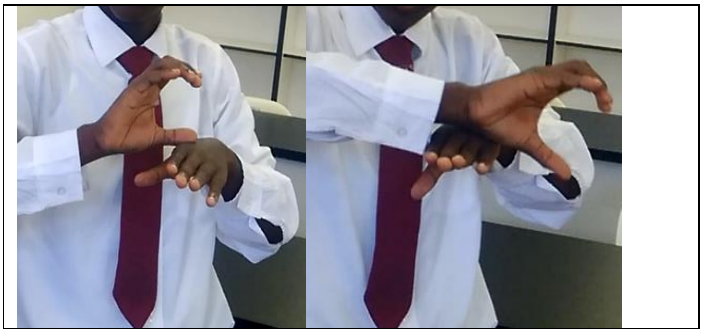

Figure 2: Illustration of 'force' though Sign Language. Mxolisi is placing the left hand flat to be a plane for the right hand. The right hand is in the form of a G clamp. Initially a thumb of the right hand is placed at the left backhand and the hand is moved,
maintaining the position of a G clamp.

In Figure 2 Mxolisi is demonstrating the word 'force' using Sign Language. Force is a scientific concept related to stimulation of one object by another, leading to movement. Mxolisi seems to have an understanding of the scientific nature of force as a vector quantity that encompasses direction and magnitude. He placed his left hand as a plane and moved his right hand shaped as a grip on top of the left hand (plane). In this action there is forceful movement and a constant direction. Both 'load' and 'force' are signed differently. Gestures from Sphelele depict resistance against gravitational force while Mxolisi's gestures show interaction between his two hands, where his right hand is moving on and against the left hand.

B. Load

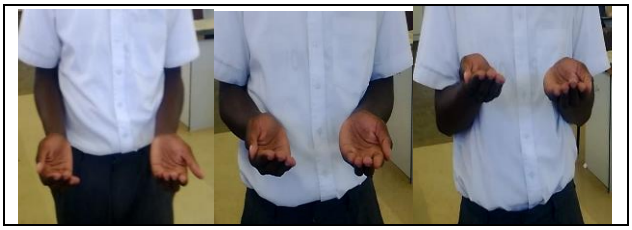

Figure 3: Illustration of the word 'load' though Sign Language. Sphelele is providing a symbol for 'load', which is a steady upward movement symbolising a lifting endeavour of an object.

In Figure 3, Sphelele demonstrates an understanding of 'load' as a concept used in the calculation of Mechanical Advantage. In this demonstration there is interdisciplinarity between Technology, Science and Sign Language, in the sense that 'load' is a quantitative measure of goods subjected to gravitational force. Sphelele could understand the concept of 'load' as it is used in Mechanical Systems, in the sense that load does not change shape, movement or size but will only be influenced by a person who can lift or push it. Hence he shows his hands moving up with the positioning of his hands indicating a lifting attempt. However, this sign used for representing 'load' misses the Technological connotation that it is a force exacted directly on the surface of an object, leading to movement. Both participants (Mxolisi and Sphelele) could fathom relative task, movement, and factions contained in the two concepts of 'force' and 'load'.

C. Division sign

Figure 4: Illustration of the word 'divide' though Sign Language. Deaf learners were captured using the division sign in explaining a mathematical approach to calculation of MA. The movement of the two figures start from the nose bridge and point at an opponent or front position.

Figure 4 presents participants showing a division sign using Sign Language. The division sign forms a crucial part of binary operations, as discussed in table 1 in section IIB. Participants display a comprehension of the sign and their gestures (body movement) reviled some comprehension and the internalisation of the concepts.

D. Area

Figure 5: Illustration of 'area' through Sign Language. Sphesihle is placing her hands 'right above left' and moving the right hand in a circular motion

Sphesihle is demonstrating the sign used to illustrate 'area' through Sign Language in Figure 5. These pictures show her right hand hovering over the left hand. This action is depicting an understanding of the amount of space within a bounded surface. 'Area' is an amount of two-dimensional space taken up by an object. Hence Sphesihle is only hovering her right hand over her left hand. The implication of this concept of 'area' to Mechanical Systems demands the effective understanding and use of formulas in different shapes. For example, rectangle, square, triangle, etc, formulas embrace a symbolic expression using numbers to express functional relationships in a single object. An understanding of the concept 'area' in Mechanical Systems enhanced comprehension of Mathematics language relations used in logical calculations of surfaces in different shapes by learners.

E. Equal sign

Figure 6: Illustration of the 'equals' sign though Sign Language. Sphelele, Mxolosi, Nosipho and Sphesihle are signing 'equal'. This is linking Mathematics language with Sign Language.

In Figure 6 participants are showing an 'equals' sign through sign language. This mathematical symbol falls within the category of binary operations. The function of the 'equals' sign is to compare two sides regardless of their composition. The equals sign is used with understanding in the Deaf classroom and is enhanced by gestures.

F. Calculations: Description of the written calculations

Calculations on hydraulic systems depended on correct formula identification, the appropriate application of Mathematics concepts and language of Mathematics. Participants understood the essence of a formula used forcalculating pressure. The implication of pressure in hydraulics and pneumatics is the same in the sense that

$$P=F/A.$$

Although some participants were not sticking to formula presentation but they were all able to follow the pattern of functional behavior of algebra in their calculations e.g. Nosipho provided the substitutions of values to the formula of

$$P1=P2$$

and followed a logical calculation of numbers.

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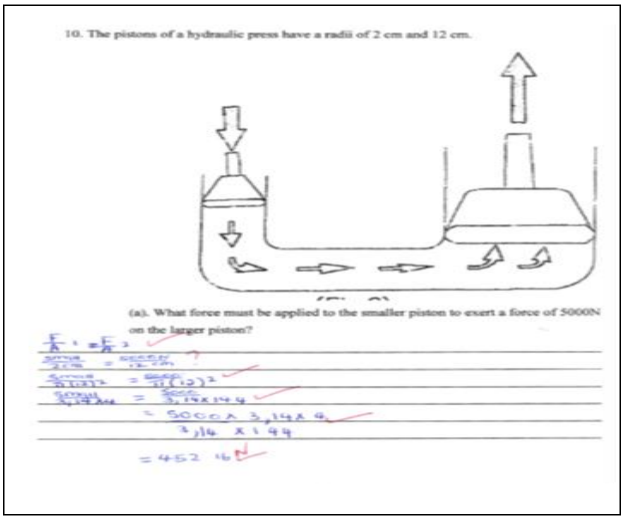

Figure 7: Nosipho's response on hydraulics.

The response of Nosipho in the second step showed a misunderstanding of the given information. Pistons of the hydraulic press were given in radius and the radius was given in centimetres. Nosipho substituted radius values in the place of areas in the second step, but in the third step she is now calculating for an area. It is not clear whether the learner understands the procedure of calculating pressure clearly.

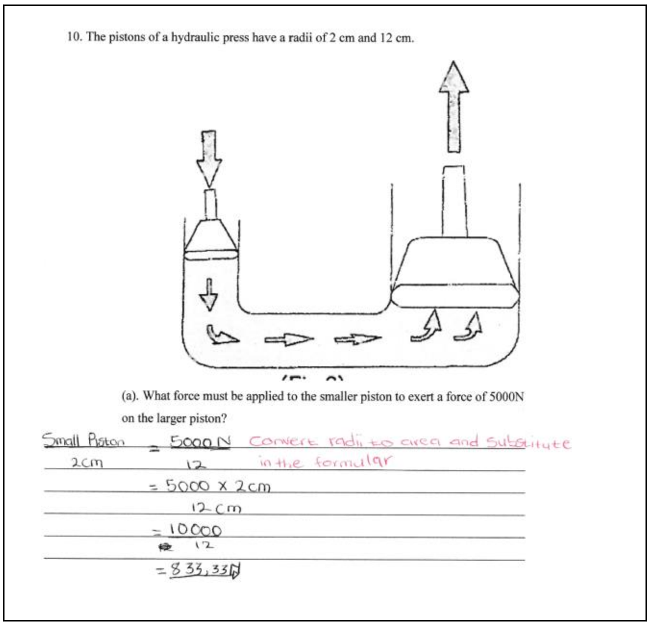

Figure 8: Zekhethelo's response on hydraulics.

Zekhethelo seem to have understood the procedure but ignored the basics for calculating pressure. She did not provide a formula for calculating pressure. She did not calculate area but instead took the raw radius data and used them in centimetres. She did not bother to convert them into metres nor calculate an area. Instead, she stuck to the procedure and ignored the principles.

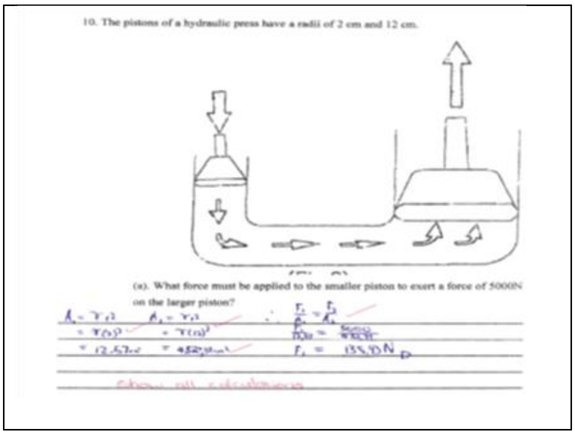

Figure 9: Mxolisi's response on hydraulics.

Mxolisi knew that he had to calculate areas before substituting them in the formula. It appears as if Mxolisi calculated an area without converting centimetres to metres as per the requirement for pressure calculation. A measuring unit for pressure is N/m2; this suggests that we completely and properly convert centimetres to metres before we calculate an area. When I asked Mxolisi as to why he did not do this, he said:

…two pistons are using centimetre. When I am calculating force, centimetres will cancel because they are equal to centimetres…

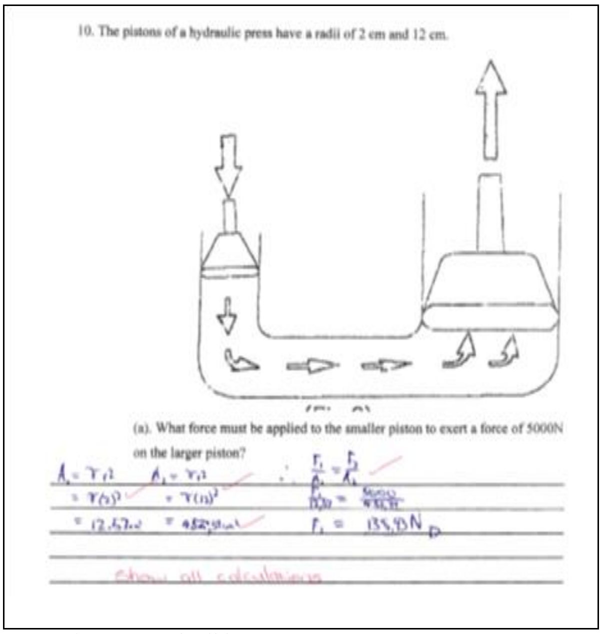

Figure 10: Sphesihle's response on hydraulics.

Sphesihle worked out the problem in the same way as Mxolisi. Both Deaf learners knew that they have to calculate an area before looking for a force required. They are not highlighting the issue of pressure in their calculation, but are more interested in finding the force required.

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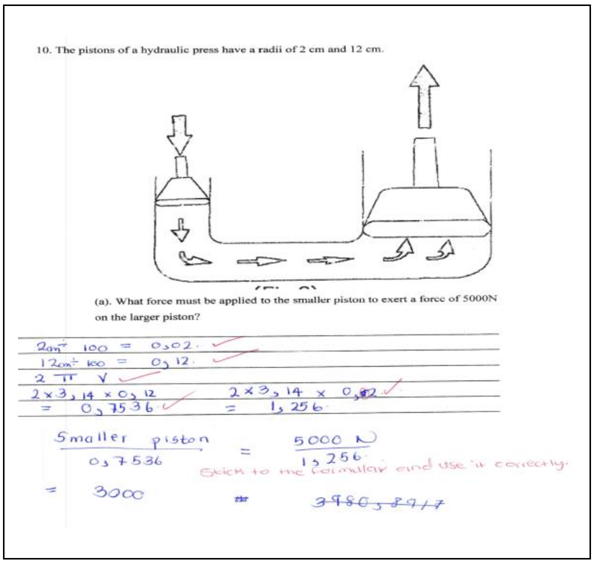

Figure 11: Sphelele's response on hydraulics.

Sphelele converted centimetres to metres and thereafter calculated areas of each piston and substituted the answer into the formula for both pressures. The different approaches observed in the responses of the Deaf learners showed an independent approach applied to Question 10. One thing that the learners all had in common is that they understood the procedure of applying Pascal's law. They were able to differentiate between the piston on the input side and the piston on the output side, and were able to correspond the values accordingly.

VI. DISCUSSION

The statement on hydraulics jack was given in English language coupled with a pictorial drawing. Measurements of both pistons were given in radii in cm. Our observation showed that hydraulics lessons were taught in line with the prescript of Technology CAPS document, foregrounding Technology literacy as oppose to vocational education. Calculations on hydraulics encapsulated intertextual approach where Mathematics text shaped Technology text. The arithmetics section in hydraulics jack problems involved Mathematics language, English as a language of instruction and symbols used in formalized text ($P1 = P2$). The first hypotheses is that Deaf learners had a good retention ability to on concepts they have engage with through Sign Language. We discovered that

Deaf learners were able to translate the content used in formalized text into Sign Language as presented in Figures 3, 4, 5, 6 and 7. Conceptual understanding of the content on hydraulics section developed an integrated corpus of knowledge from Mathematics and other sciences essential for skills, procedures and abilities to formulate measurable ideas for problem solving. Deaf learners posesed some vocabulary from Mathematics language that provided clarity and simplicity when they were translating the given statement into a formula as a formalized text. Their visual-spatial was adequately enhanced. They were able to remember information presented in a physical space with all finer details and text with pictures was making more sense to them. Their bodies were used as the reliable resource for communicating and reinforcing information. Through our informal discussion during breaks, we discovered that Deaf learners had been sharing classes and subject for quit sometime as they were in Grade 9. Our observation reviled that comprehension of concepts in Deaf learners was supplemented by peer communication since their understanding for each other was based on trust. Their experience in sharing classes had a positive academic influence through establishing bonds and trust with one another as an evidence of interdependency during their lifelong learning. Deaf learners were very attentive to movements and they were better involved in lessons where discussions were done through Sign Language. Deaf learners used Sign Language and finger spelling concurrently to facilitate their learning and to unpack any ambiguity encountered.

The second hypotheses is that when tasks involve single stimulus e.g. identifying formulas required for calculating pressure in the system of hydraulics in relation to the Law of Simple Machine (Pin = Pout), Deaf learners were able to recall formulas. Application of Pascal's principle to hydraulics system was the last exercise done to consolidate the learning of hydraulics system. Calculation exercise was an individual approach highly influenced by knowledge gained through various experiences e.g. demonstrations, simulations and presentation of lessons in hydraulic system. Calculations were done in class to reinforce an understanding of hydraulics system to Deaf learners. As part of learning in Technology, Deaf learners were not asked to derive formulas but to identify them for adequate use. We discovered that deaf learners were good at retrieving smaller portions of work that relate closely to Sign Language e.g. signs for scientific words and signs for binary operations. Sign Language and formulas are similar in that Sign Language is not using long sentences to present the case and formulas use specialised shortened language to present the case. For that reason, the acquaintance of Deaf learners with formulas is somewhat a reduced elementary knowledge for calculations in hydraulics system.

The third hypotheses is that when task completion depend on integration knowledge selecting from multi-dimensional information, Deaf learners encounter a challenge. It was obligatory for Deaf learners to recall relevant properties of a circle immediately they see words "piston, and radii". Properties of a circle were not taught in Technology but served as an underlying factor for calculating surface areas of pistons in the given statement. The following properties identify a circle as an interdisciplinarity of Technology and are only covered in Mathematics.

- Circumference – Total distance around the circle.
- Center – A point inside the circle that provides equidistance to any line drawn from it to the circumference.
- Diameter – Straight line inside the circle passing through the centre to the direct opposite sides of the circumference of the circle.
- Radius – Straight line starting from the centre of the circle to any point of the circumference.

These properties needed to be considered as a major aspect of interdisciplinarity in calculating the surface areas of the pistons in hydraulics jack.

Deaf learners were expected to calculate the missing components at the input and the output side, using the properties of a circle. In the formula used for calculation pressure in and pressure out, Deaf learners had to go through the:

- Convection of cm – m on a given information
- Calculation of an area a circle using radians without mention and
- The substitution of the value of an area in the formula below

Pascal's law
$P_1 = \frac{F_1}{A_1} \quad and \quad P_2 = \frac{F_2}{A_2}$

Deaf learners turn to recall disconnected potion of texts, suggesting a lack of semantic integration and a deeper processing of meaning. Deaf learners developed a vocabulary related to concepts used in in hydraulics and used them with understanding, for example load, effort, force, equal sign, division sign and multiplication sign. Although Deaf learners were able to recall formulas, they showed various limitations in Mathematics fluency. Above the formula retention, it was expected of them to adhere to the procedure of changing centimetres to metres on the given dimensions of pistons as there were given in centimetres. Data given for piston sizes were in radii and had to be used to calculate the surface area of the pistons.

Nosipho wanted to calculate the surface areas and the input force required simultaneously. She did not separate each aspect and substituted thereafter e.g. calculating the surface area of both pistons after changing given measurements from centimetres to metres. Her procedures showed a conceptual understanding of hydraulics calculation using Pascal's principle through the application of the Law of Simple Machine (Win = Wout).

Zekhethelo knew the formula according to the Law of Simple Machine through memorization. But experienced some limitations in changing centimetres to metres before substituting that information to the formula. She failed to integrate the conceptual understanding of area in a circular shape with the prescripts of the unit of measurement in pressure as Nm-2. This experience is usually not highlighted but comes as an acknowledgement of the usefulness of the interdisciplinarity in Technology and Mathematics. She took the raw data without scrutinizing them and yielded to the wrong answer.

Mxolisi knew the significance calculating the surface area in both pistons but was limited in acknowledging the essence of changing centimetres to metres. He ignored the appropriate procedure for calculating surface areas of pistons in a sense that would adhere to the required unit of measurement for pressure in Nm-2 with an argument that "centimetres will chancel one another".

Sphelele's approach was correct although clustered with many calculations all over the place. Calculations were not logically written, leading him to confusion for logical calculation. Sphesihle used the formula for calculating pressure. She substituted radius in the formula for calculation area without changing them from 'centimetres' to 'metres' as suggested by the unit of measurement in Pascal's principle (Nm-2).

VII. CONCLUSION

From data analysis we noted that Deaf learners were able to compute given values in the formula for calculating pressure in a bounded system in accordance with the Law of Simple Machine. The conversion of 'centimetres' to 'metres' and the calculation of surface areas of pistons were fundamental in problems related to pressure. Deaf learners did not place much significance on the conversion of 'centimetres' to 'metres' as a prerequisite for the unit of measurement for pressure Nm-2. As a result we identified the need of fundamental Mathematics that will enforce skills in the procedural fluency.
Since Deaf learners were showing better strength on information reinforced through Sign Language, curriculum should embrace a form of assessment as a presentation through Sign Language that will include them reasonably. This will ensure that Deaf learners are adapted to Technology curriculum as envisaged and their tacit knowledge will be recognised.

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