The role of study material in the Professional development of Physics Teachers in Distance Education

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Research has been done for the past 4 years with 75 Physical Science teachers to construct and test a holistic model for professional development via Distance Education. Three dimensions were targeted that need development, namely, the teachers' physics content knowledge, their teaching approaches and professional attitudes. In the first phase of the research, baseline data were obtained to see if there is a problem in these dimensions. In the second and third phase a model was developed and trialled each time with a new set of teachers in the urban and rural parts of South Africa. In the fourth phase an analysis of the model was done. Evidence shows that the teachers changed from being caught in a vicious circle of poor content knowledge, lack of confidence and enjoyment and unwillingness to spend time on task (poor professional attitudes, ineffective teaching approaches) to being part of a virtuous circle of improved content knowledge, more confidence and enjoyment and willingness to spend more time on task (better professional attitudes and effective teaching approaches).

One of the elements of the model that was found to be the key to success was the study material. An integrated approach of developing content knowledge and pedagogical content knowledge simultaneously was followed. It was also designed in such a manner that the teachers can use it in the classroom interactively and improve their teaching and learning.

Introduction

Distance Education can help solve some of South Africa's problems by enabling students to learn wherever they are, at their own pace, not taking them out of their classrooms and enabling them to learn while earning a living. This is not always easy because the students sometimes have family commitments, may feel isolated and lost.

Physics teachers need professional development and research has been done to construct and test a holistic model. The dimensions of the proposed model for professional development are content knowledge, teaching approaches and professional attitudes that need development simultaneously. The elements of the distance education program are study material, assignments, reflective journals, workshops and peer support.

In order to illustrate the role of the study material as one of the elements of this professional development program, three examples from the study guide will be extracted and discussed. The study material was designed for teachers teaching Grade 10 – 12 and the following were identified that needed to be addressed. The language of the study guide and the graphs and figures must be simple and understandable. The teachers' content knowledge as well as their conceptual understanding must be deepened and their teaching skills improved. Furthermore, other areas that need to be addressed are thinking and reasoning skills (Arons, 1979, 1984, 1990), problem solving skills (Schultz & Lochhead, 1991) and experimental skills (Grayson, 1996). To ensure that these teachers become life-long learners their metacognitive skills, (Nickerson, 1985) must be developed too.

During a period of 3 years, 75 Physical Science teachers who enrolled for the modules have worked through the guides.

Methodology

To construct a model for the professional development of physics teachers in South Africa the following process was used that was developed by Loucks-Horsley et al. (1998) see Figure 1.

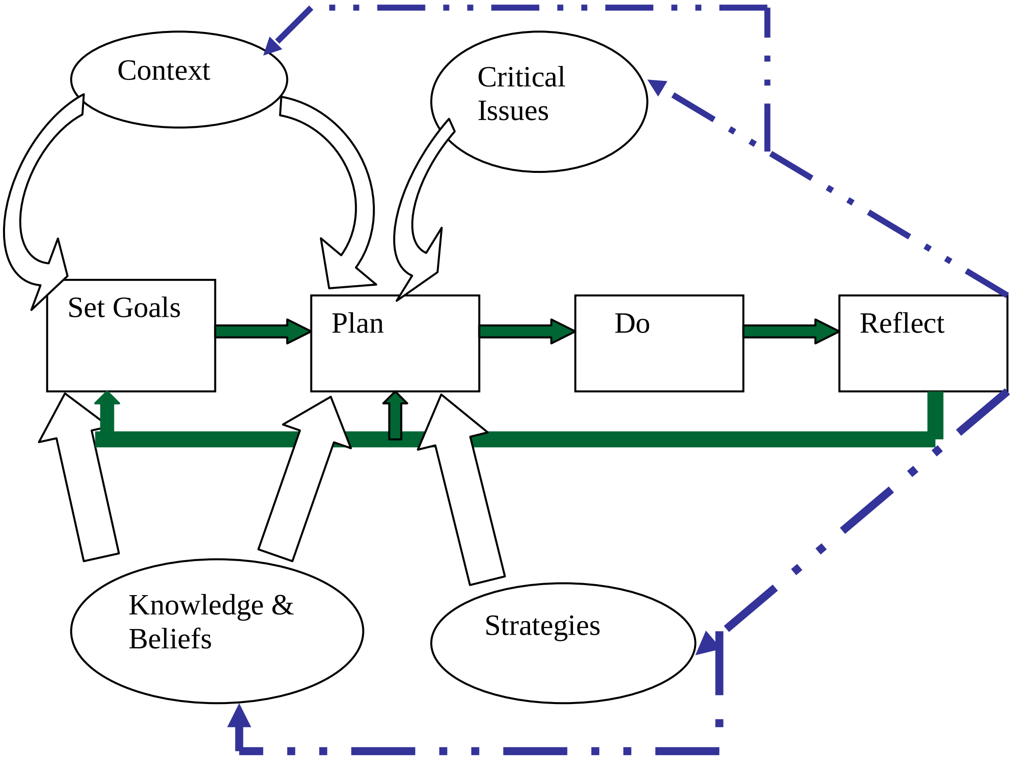


Figure 1. Framework for Designing Professional Development

The knowledge and beliefs that had an influence on the goal setting and planning of each phase stayed the same for the three phases. Knowledge was regarded as researchers' knowledge about learners and learning in general, teachers and teaching, change and the change process, the nature of the disciplines of science and the principles of effective professional development. Researchers' beliefs were seen as the core values the designer of the professional development program was committed to, namely, that content knowledge, professional attitudes and teaching approaches need development simultaneously.

With each phase the context changed. In the first phase we worked with science teachers in urban schools and in the second and third phase with teachers in urban and rural schools. Other factors that also needed to be considered in the context included curriculum instruction, assessment and learning environment, resources such as time, money, the expertise of the available professional developers and community support.

Critical issues such as equity to ensure that all teachers had equal opportunity to be better science teachers as well as building a professional community and the capacity of sustainability were taken into consideration. Strategies such as workshops, peer coaching, and getting teachers to experience an inquiring approach into science were used.

For each phase new goals were set taking knowledge and beliefs, the context, strategies etc. into consideration. The teacher development program was planned and run for a year. Results were analysed to determine what the effect of the program was on the teachers. Reflection regarding the model was done in order to make changes for the new phase that had to be trialled on a new set of teachers.

In order to illustrate the role of the study material as one of the elements of this professional development program, the following examples have been extracted from the study guide Physics for Teachers I in order to illustrate how the teachers conceptual understanding has been developed.

The following abbreviations will be used: Reasoning and thinking skills as (RT), Problem solving skills as (PbS), Experimental skills as (ES), Teaching skills as (TS) and Metacognitive skills as (MS) in the example taken from a Study guide and the discussion will be given in italics.

Example 1

An experiment, **"**Forces on a trolley moving with constant velocity" was given in the form of a worksheet. The aim was not given; rather the teachers had to formulate it at the end of the experiment.

The diagram shows the experimental set-up.

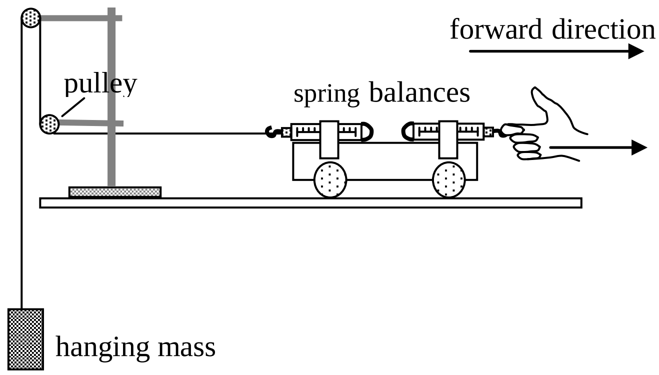


Figure 2. Experimental set up

Identify the forces on the trolley:
(a) Draw and label the vertical forces on the trolley.
(b) Draw and label the horizontal forces on the trolley.

Comment: In this part the teachers are developing their conceptual understanding to see if they can identify the forces correctly. Furthermore their PbS are developed by asking them to represent a problem situation via drawings.

Before carrying out the experiment of 4 runs with a different velocities, namely no velocity, moving slowly, moving with a medium velocity, and moving fast they had to make some predictions, using symbols: < , >, or = as well as << for much smaller, or >> for much bigger.

Table 1

Velocity of trolley	**Predicted** (before experiment)	**Measured** (after experiment)
Zero	$F_{forward}$ . . . . $F_{backward}$	$F_{forward}$ . . . . $F_{backward}$
Small	$F_{forward}$ . . . . $F_{backward}$	$F_{forward}$ . . . . $F_{backward}$
Medium	$F_{forward}$ . . . . $F_{backward}$	$F_{forward}$ . . . . $F_{backward}$
High	$F_{forward}$ . . . . $F_{backward}$	$F_{forward}$ . . . . $F_{backward}$

Furthermore they had to predict how the forward force required for a small velocity compares to the forward force required for a high velocity by using the same symbols.

Table 2

Predicted (before experiment)	**Measured** (after experiment)
$F_{forward\ high\ velocity}$ . . . . $F_{forward\ low\ velocity}$	$F_{forward\ high\ velocity}$ . . . . $F_{forward\ low\ velocity}$

Comment: During the prediction part of the experiment, the teachers develop their PbS by organizing their knowledge according to principles that focus on the solution of the problem at hand.

They then had to take measurements as a team.

Comment: In performing the experiment their ES were developed by manipulating the apparatus, taking measurements, making correct and careful observations

Now, the teachers had to go back to Table 1 and fill in the column under the heading 'Measured (after the experiment)' and use the findings of the experiment.

Comment: In this part MS were developed. Previously they had to predict what would happen, and then check what happened, do a reality test after performing the experiment by comparing with their prediction. In this way they can monitor and control their own attempt to perform an intellectually demanding task. Furthermore, there ES were developed by analysing the data appropriately.

The following questions were asked to develop a deeper insight based on the findings of experiment 1:

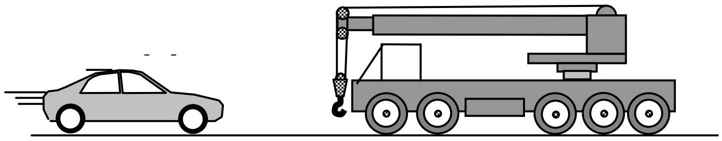
1. According to many people you need a net force to keep an object going. Is this belief in agreement with the findings of experiment 1?
2. How can you increase the backward force? If you did this what forward force would be required to maintain a constant velocity? Suppose we make the backward force smaller what forward force would be required to maintain a constant velocity? Suppose we make the backward force 0 N. What would be the forward force required to maintain a constant velocity?
3. Suppose we have a trolley without any backward force (so no friction either). What is the forward force if it moves with a constant velocity? Suppose the trolley is moving right now. What happens to the trolley over a long period of time?

Comments:
In all the above questions the teachers' conceptual understanding were developed as well as their skill to perform hypothetico-deductive reasoning as one of the RT. were developed: distinguish inferences from observations, make appropriate approximations, translate between physical phenomena and representations, give phenomenological explanations, perform proportional reasoning and reason by analogy.

The above example illustrates the use of a specific teaching strategy and furthermore the following TS such as stimulating learning as a group activity, teaching for conceptual understanding, setting of problems to develop problem solving skills, involving learners in practical work as well as using predictions to expose current understanding were demonstrated in this example.

The following two examples taken from the study guide illustrate that by answering the questions in Example 2 (a), to identify the forces in interactions, you are guided to develop a conceptual understanding and see for yourself how in Example 3 the action and reaction force used in textbooks are misleading.

Example 2



(a) Car A is about to collide with a stationary crane B. Compare the magnitude of the forces: $F_{A\ on\ B}$ and $F_{B\ on\ A}$.
(b) The damage done to car A is much bigger than the damage to crane B, so people say that Newton's law really cannot be true. What is your response?
(c) Statement: *People confuse cause and effect*. Check your answer to (b) and explain what is meant by the statement in this particular problem.

Comment:
In part (b) a misconception that is made frequently is addressed and in part (c) this misconception is addressed.

Example 3

(a) In many textbooks the pair of forces in an interaction is called the action and reaction force. Explain why these names are misleading.
(b) Given that it is better to avoid using the terms action and reaction force what method is best to identify the forces in an interaction such that pupils develop a clear understanding?

Comment: By answering these two questions it can be clearly seen how misconceptions can be elicited and addressed. These two examples illustrate how content knowledge and pedagogical content knowledge have been intertwined in the study guide.

Comments from the journals of teachers participating in the program

In order to illustrate how the study material helped the teachers to change from poor content knowledge, lack of confidence and enjoyment to improved content knowledge, more confidence and effective teaching approaches the following quotations from the teachers journals after completing the program.

> "Your study materials are just like walking Physics lecturers, they are excellent, and they explain the concepts clearly. They correct our misconceptions in Physics. They also correct the misconceptions our learners have."

Some of the teachers are teaching in the rural parts of South Africa and not only did they read the study material but also implemented in their classroom.

> "The unit is well organized in the guide and easy to read and implement the suggested approaches. Most of the suggestions can be adapted to a poor environment where learners found themselves without proper support systems."

Apart from improving the teachers' content knowledge and confidence in the classroom, another aim when we developed the study material was that the language must be simple and understandable. This seems to be the case when reading this teachers journal.

> "The concepts are explained in a language which is not complex and not too different from what one learned previously. The benefit is on additional knowledge provided in the unit, which enable a teacher to be more confident in presenting lessons. This approach make one like the subject more and more and therefore always to enjoy reading and searching for more knowledge to supplement the previous gathered knowledge."

In the above journal entry the teacher shows signs of capacity building when he "searches for more knowledge" and metacognition when he judges his own understanding and realises his shortcomings.

Conclusion

One of the elements of the professional development program for physics teachers was the development of study material. The success of the distance education study material was in designing it with an integrated approach of developing content knowledge and pedagogical content knowledge. This was illustrated in the three examples taken from the study guide, Physics for Teachers I.

Furthermore it was designed for teachers to use interactively and in their classroom to improve their teaching and learning and from the above comments taken from some of the teachers' journals it can clearly be seen that the study material deepens the teachers' conceptual understanding and is used in their classrooms interactively. It does not only provide a resource for the teachers but also for the learners.

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