

The Use of Hand Puppets to Increase Intrinsic Motivation during Science Learning of 6th and 7th Grade Learners in Dikgale, Limpopo Province, South Africa: A Case Study

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Abstract

One of the most important psychological concepts required for enhanced learning is motivation. This is especially true for science, which is seen by learners as being difficult. This study investigated the motivational changes with regard to studying science and the gender and age differences when using hand puppets in the science classroom. In order to examine this, a 7-week intervention involving the teaching of science by means of hand puppets was conducted in two Grade 6 and two Grade 7 classes in rural-based Dikgale, Limpopo Province, South Africa. The learners' motivation was assessed in terms of basic psychological needs, intrinsic and extrinsic motivation, with a questionnaire before and after the intervention. Data were analysed using a paired sample t-test, an independent t-test and a MANCOVA. The results show an increase in basic psychological needs and intrinsic motivation, and a decrease in extrinsic motivation for science, after the use of hand puppets. In addition, it appears that there are no gender and age differences regarding motivational change when using hand puppets in science education. It is therefore concluded that hand puppets are a promising teaching method that positively affects the motivation of school learners studying science. Thus it is recommended that further

research in the form of an experimental longitudinal design be undertaken to ascertain long-term motivational changes.

Keywords: astronomy teaching; hand puppets; science learning; motivational change; intrinsic and extrinsic motivation

Introduction

One of the most important psychological concepts to enhance learning is motivation (Vallerand et al. 1992). Motivating learners is related to a variety of outcomes such as persistence, achievement, creativity, curiosity and performance. Furthermore, motivation is of great importance in learning (Deci and Ryan 1985; Guay, Ratelle, and Chanal 2008). When motivation research is done, the Self-Determination Theory (SDT) is unavoidable. Deci et al. (1991) stated that if the Self-Determination Theory is applied correctly in education, it can lead to an interest in learning, a valuing of education and gaining confidence in capacities and attributes.

The most important type of motivation is intrinsic motivation. It is widely acknowledged that intrinsic motivation has important outcomes that cannot be ignored or neglected. The findings of different studies on this subject are promising. Some studies have linked intrinsic motivation to positive academic performance (Grolnick, Ryan, and Deci 1991; Pintrich and De Groot 1990), while others have shown that there is an increase in conceptual understanding (Benware and Deci 1984; Grolnick and Ryan 1987) when learners are motivated. Krapp (1989) claimed that learners with high intrinsic motivation show more interest, excitement and confidence when they learn.

People who are intrinsically motivated do things for themselves, because they experience joy, satisfaction or pleasure by carrying out a task. There is no need for rewards, and this differs greatly from extrinsic motivation. With extrinsic motivation, the reward comes from an outside source. In contrast, intrinsic motivation comes from an internal source. Giving tangible rewards, both material and symbolic, is a widespread phenomenon with educators. Yet a meta-analysis of Deci, Koestner, and Ryan (2001) concluded that rewards undermine the intrinsic motivation for the rewarded activity.

Intrinsic motivation could thus be a key to success in science classes. Weber and Patterson (2000) emphasise the relationship between motivation and interest. Interest is an important factor in the educational field because the current interest level of science learners might affect their future career paths. Tai et al. (2006) state that an interest in science early in children's lives influences their decision to pursue a science-related career later in their schooling years. They also found that learners who have an interest in science in Grade 8 are three times more likely to obtain a college degree in a science field than those who did not show that interest.

Basic psychological needs have a direct relation with personal well-being. If these needs are fulfilled, one's well-being increases. In contrast, if these needs are countered, one experiences negative consequences. If individuals cannot satisfy their needs, their motivation as well as other cognitive, affective, and behavioural indicators are negatively affected (Deci and Ryan 2011).

Pintrich (2003) suggests the need to investigate motivation in new ways in classrooms. The value of hand puppets has already been established in drama (Asher 2010; Bardakci 2011), social (Lowe and Matthew 2000), and language education (Özdeniz 2005; Stuyvaert 2010; Thorp 2005). However, research on using hand puppets in science education is still in its infancy. Nevertheless, the studies that do report about this topic are very promising. Simon et al. (2008) showed that the use of hand puppets increased motivation, but this has only been proven in the UK. It is not certain that the evidence from this project is generalisable to other non-European contexts, such as South Africa, hence the need for this study.

The didactical method of teaching with hand puppets is related to the principles of vicarious learning, observational learning and modelling, which are part of the broader social learning theory of Bandura. When children observe the interaction between the hand puppets, they learn vicariously from the hand puppets who act as models for these children. Moreover, the use of hand puppets increases the learners' interest and curiosity (Lowe and Matthew 2000). In this manner they become intrinsically motivated, and the learning process becomes more attractive. Finally, hand puppets create a non-threatening environment, where learners will be less frightened to answer questions and to participate (Stuyvaert 2010).

Although research about using hand puppets in science is still rare, several advantages have already been noted. First of all, the engagement and motivation of the children increased when puppets were used to teach science (Simon et al. 2008). Besides, hand puppets are particularly effective for engaging reluctant speakers, such as shy children (Asher 2010; Keogh et al. 2006; Naylor et al. 2007a; Özdeniz 2005). Furthermore, the use of hand puppets in the science lesson will change the teaching style from an educator-centred to a more learner-centred approach. The puppets are able to stimulate the kind of talk that involves reasoning and argumentation instead of using numerous questions that require recall (Simon et al. 2008).

When using puppets, special characters can be created that present "problems" to the children. In this manner, children become engaged and are stimulated to solve problems and ask or answer questions. In addition, hand puppets have proved to be effective across all primary age groups (Naylor et al. 2007a; Stuyvaert 2010). Therefore, we considered this intervention as suitable for both Grade 6 and Grade 7 learners.

South African learners generally tend to do poorly in international science indexes. For most the problem starts in primary school, where at under-resourced schools, science is

often taught by non-science-trained educators co-opted to teach this discipline due to a lack of adequately trained graduate educators. Here science is being conveyed in an uninspiring manner and by promoting rote learning (learning without understanding). Thus this research was initiated to ascertain if hand puppets could increase the motivation of learners in the learning of science. Therefore, the aim of this study was to find out whether hand puppets raise the intrinsic and extrinsic motivation of learners, as well as their basic psychological needs, and whether these changes are gender specific and limited to a certain age group.

Theoretical Framework

The importance of motivating students has already been emphasised in the introduction. Motivation is a very broad term and much research conducted on this topic attests to that. Urdan and Schoenfelder (2006) state that academic motivation reflects a complex interaction of numerous personal and situational factors. This statement shows how complicated motivation is. In this research, we narrowed it down and used the Self-Determination Theory (SDT) as our base in order to understand it better.

Deci and Ryan (2011, 416) explain SDT as “an empirically derived theory of human motivation and personality in social contexts that differentiate motivation in terms of being autonomous and controlled.” With motivation they mean that people have the intention to accomplish something. When motivated, you have a clear vision of the desired end and the will to get to this end. Within this theory, they say that there are different types of motivational behaviour. These vary to the extent that they are self-determined versus controlled. The distinctions they make between the different types of motivation encompass motivation, extrinsic motivation and intrinsic motivation. The three types are placed on a continuum of regulation. Motivation is placed at the beginning of the continuum, when one has no regulation. For the next type, extrinsic motivation, they distinguish between four different types of extrinsic motivation. These different types each have another level of regulation. The regulation ranges from heteronomous control to autonomous self-regulation. These different types (from left to right) are external regulation (the least autonomous form of extrinsic motivation), introjected regulation, identified regulation and integrated regulation. In terms of intrinsic motivation, they identify intrinsic regulation (Deci and Ryan 1994; Ryan and Deci 2002).

Another important concept for the SDT is that of the basic psychological needs. These basic needs have a direct relation with personal well-being. If these needs are fulfilled, one’s well-being increases. In contrast, if these needs are countered, one experiences negative consequences. If individuals cannot satisfy these basic needs, then their motivation as well as other cognitive, affective, and behavioural indicators are negatively affected (Deci and Ryan 2012).

There are three needs that are important for intrinsic and extrinsic motivation: competence, relatedness and autonomy. Deci and Ryan (2012) define the competence need as the desire to master and to be competent, autonomy as the desire to be in control and to feel that you can determine things on your own, and relatedness as a desire to belong to a group. These needs give opportunities to predict variables in the social environment that affect people's intrinsic and extrinsic motivation (Deci and Ryan 1994). Ryan and Powelson (1991) argue that relatedness and autonomy are fundamental for learning, but that the institutionalisation of education overshadowed these two basic needs. Of the three basic needs, competence and autonomy (or self-determination) have been connected with intrinsic motivation. According to Pintrich (2003), these needs are important for all humans in all cultures and apply across all situations. This means that the needs apply to all students regardless of the context or culture, and so too for students in South Africa.

Gagne and Deci (2005, 331) define intrinsic motivation as “an activity from which people get spontaneous satisfaction because they find it intriguing.” People who are intrinsically motivated do things for their own sake, for example, because they experience joy, satisfaction or pleasure by carrying out a task. There is no need for rewards or constraints, and this is the big difference with extrinsic motivation. With extrinsic motivation, the reward comes from an outside source. In contrast, with intrinsic motivation, it comes from an internal source. As mentioned above, giving tangible rewards, both material and symbolic, is a widespread phenomenon among educators. Yet a meta-analysis of Deci, Koestner and Ryan (2001) concluded that rewards undermine the intrinsic motivation for the rewarded activity.

Methodology

Participants

The sample consisted of 88 learners, comprising 49 girls (55.7%) and 39 boys (44.3%), with a mean age of 12.73 years ($SD = 1.23$). The participants were 6th and 7th graders from two randomly chosen rural-based primary schools in the Dikgale area of the Limpopo Province in South Africa. Both schools are no-fee schools, which places them more or less on the same academic standard. From these learners, 40 (45.5%) were 6th graders and 48 (54.5%) were 7th graders. The intervention took place in the last term of the school year and took seven weeks to complete. It was conducted during science periods. The schools had the choice to voluntarily take part in the research.

Research Design

This research study investigated if the basic psychological needs, intrinsic and extrinsic motivation increased for learners during the intervention. A quasi-experimental design was followed where findings were based on focus groups, observations and interviews with school learners. The participants were from two different schools, and in each school the Grade 6 and Grade 7 learners were part of the intervention. The pre-test was

taken as the control group and served as a baseline study to indicate where the learners were at, as educators at the schools felt it to be unfair not to apply the intervention to all groups. Before the intervention started, the researchers observed the educators and learners for three days. The purpose of these observation lessons was merely to familiarise themselves with the learning environments before getting started with the teaching through puppets. The intervention started at the beginning of September and ended at the end of October, the last term of the South African school year.

The study conducted two measurement points during the intervention: the pre-test at the beginning (8 September 2016) of the intervention, and the post-test at the end (30 October 2016) of the intervention. For both pre- and post-test, the same questionnaires were used. Next, the interviews were conducted with learners. In every class three learners were interviewed. Weak, average and strong learners were selected by looking at the mean grades of the learners. Finally, the educators of the classes were interviewed.

During our 7-week intervention, two trainee educators/teachers used two large hand puppets to teach astronomy to 6th and 7th grade primary learners according to the South African school curriculum. The two hand-held puppets were astronomy-related characters: an astronaut and an alien, and were respectively 1,70 cm in height. The trainee educators and the learners had no prior relationship, and saw each other for the first time in the first observation lesson prior to the intervention. According to prior research (Simon et al. 2008), the astronaut puppet took on the role of an expert and the other puppet (the alien) took on the role of someone who needed expert advice.

Each lesson began with an introduction by the puppets where the alien puppet asked revision questions about the previous lesson, and the other puppet (the astronaut) explained the lesson goals. In every lesson, the puppets discussed or talked about astronomy. The alien puppet always asked many questions. He asked either the other puppet or the learners, whereupon the astronaut puppet responded and explained astronomy-related information in such a way that learners could understand more clearly.

Besides the hand puppets, other teaching methods and pedagogical principles that emerged from previous research (Gallenstein 2005; Pintrich 2003; Urdan and Schoenfelder 2006) were used during the intervention to motivate the learners. The methods and principles included the following: giving stimulating and interesting tasks with varying activities and materials, conducting cooperative group work, using formative assessment forms (tasks, questions, tests, exercises and group work) provided with immediate feedback, and creating an autonomy-supported learning environment. In addition, an astronomy workbook, with drawings of the puppets and a clear structure, was made for use during this intervention. All these teaching methods and the pedagogical principles were viewed as supplementary to the main use of the puppets. The main educational content was designed to form a booklet that contained all the exercises and other material. Each learner received a copy.

Instruments

This study mainly used a questionnaire that was adapted as a measurement tool to investigate learners' motivation. As a supplementary instrument, the investigation also made use of interviews with selected learners. The participating learners were asked to complete a pre- and post-test. The questionnaires in the pre- and post-test addressed the same questions. The questionnaire addressed general questions, such as age, gender, grade and other questions about motivation. Before testing the reliability of the different scales, the data file was cleaned. In the questionnaire there were reverse items that addressed the same question, but one of them was negatively formulated. By deleting the participants who did not fill in these questions consistently, a cleaner dataset was obtained. In the questionnaire four items focused on extrinsic motivation (for example, "I study science because I'm supposed to do it" [Vansteenkiste et al. 2009]). These four items were answered on a 4-point Likert scale that ranged from zero (totally don't agree) to three (totally true). Cronbach's alpha for the four extrinsic motivation items was 0.40 for the pre-test and 0.66 for the post-test respectively. By deleting the item "Others, parents, friends, teachers ... expect from me that I learn science" the reliability increased, and for the three items a Cronbach's alpha of 0.45 for the pre-test and 0.73 for the post-test was obtained. In addition to this, the questionnaire had four items about intrinsic motivation (for example, "Studying sciences is fun" [Vansteenkiste et al. 2009]). These four items were also answered on a 4-point Likert scale with the same range from zero (totally don't agree) to three (totally true). The intrinsic motivation scale was found to be rather weak for the pre-test (4 items; $\alpha = 0.58$) and reliable for the post-test (4 items, $\alpha = 0.64$).

The questionnaire also addressed items that measured the three basic psychological needs. Seven different items were related to learners' autonomy (for example, "When I am in the science class, I have to do what I am told" [Baard, Deci, and Ryan 2004]). These questions were answered on a 4-point Likert scale with a spectrum from zero (totally don't agree) to three (totally true). Cronbach's alpha for the autonomy scale for the seven items was 0.04 for the pre-test and 0.15 for the post-test. For measuring relatedness, eight items were used (for example, "People in the science class care about me" [Baard, Deci, and Ryan 2004]) and for the competence scale six items were used (for example, "People I know tell me I am good in science" [Baard, Deci, and Ryan 2004]). Both of these scales had the same range from zero (totally don't agree) to three (totally true). The Cronbach's alpha for the relatedness scale was weak for the pre-test (8 items; $\alpha = 0.38$) and the post-test (8 items, $\alpha = 0.42$). Also, with the competence scale, a weak Cronbach's alpha was found for the pre-test (6 items, $\alpha = 0.23$) and the post-test (6 items, $\alpha = 0.44$). The reliability of the three scales measuring basic psychological needs for the pre- and post-test was rather weak. Therefore, we decided not to use those scales separately but created one scale of basic psychological needs. There were 21 items and the Cronbach's alpha for the pre-test was 0.25 and 0.63 for the post-test. When the three items were deleted, we found a stronger reliability for the pre-test (18 items, α

= 0.32) and the post-test (18 items, $\alpha = 0.70$). For an overview of the different scales and their reliability see Table 1.

Table 1: The items, Cronbach’s alpha and an example of the different scales.

	<i>Scale</i>	<i>Items</i>	α	<i>Example</i>
Pre-test	Extrinsic motivation	3	0.45	<i>I study science because I’m supposed to do it</i>
	Intrinsic motivation	4	0.58	<i>Studying sciences is fun</i>
	Basic psychological needs	18	0.32	<i>People in the science class care about me</i>
Post-test	Extrinsic motivation	3	0.73	<i>I study science because I’m supposed to do it</i>
	Intrinsic motivation	4	0.64	<i>Studying sciences is fun</i>
	Basic psychological needs	18	0.70	<i>People in the science class care about me</i>

Note. α = Cronbach’s alpha

It is remarkable that the reliability of these scales was only average and even weak for some scales. This, however, does not mean that the questionnaire and the scales were not good and that we cannot use them again. In previous research where the same scales were used, a high reliability was found (Baard, Deci, and Ryan 2004; Vansteenkiste et al. 2009). Next to this, it is noticeable that the scales in the post-test had a higher reliability than those from the pre-test. Both remarks can be due to the fact that the learners received less help and explanations when filling in the pre-test questionnaire. In addition, the home language of the learners is different from the language used in the questionnaire. The English language barrier is stated by a student: “But sometimes the English is difficult, but I learn it here in the class. But Sepedi is easier because that I talk at home.” Although science should be taught through the medium of English, educators often used code-switching in their lessons (Setati et al. 2002). During the intervention, only English was spoken. The learners’ English could thus already have improved after a 7-week immersion in English; but this remains unknown.

Data Analysis

Transformations in the data were needed; thus before analysing the data, new variables were computed, namely, the means of intrinsic motivation, extrinsic motivation and the basic psychological needs in the pre- and post-test.

The Impact of Hand Puppets on Intrinsic and Extrinsic Motivation, and Basic Psychological Needs

This study investigated whether the use of hand puppets increased the extrinsic motivation, the intrinsic motivation and the basic psychological needs in relation to learning science for 6th and 7th grade learners. For every new computed variable, we compared the means from the pre- and post-test. Afterwards, a paired sample t-test was done, where the variables from the pre-test were paired with the same variables from the post-test, to see if there was any significant difference. Before analysing the paired sample t-test, the assumption of normality was checked. The degree was also calculated to know the practical significance. The study further looked at the minimum and maximum variance of the pre- and post-test to get a more comprehensive understanding. Because the assumption of normality was not clearly met, a non-parametric test was also done, namely the Wilcoxon signed-rank test, to see if the results pointed in the same direction.

The Impact of Hand Puppets on the Intrinsic and Extrinsic Motivation, and Basic Psychological Needs of Boys and Girls

The study scrutinised the results to see if there was a significant difference in the motivational change regarding extrinsic motivation, intrinsic motivation and the basic psychological needs between boys and girls. Before continuing with the data analysis, a new variable was computed. This variable showed the difference between the mean of a construct for the pre-test and the mean of that same construct for the post-test. An independent t-test was conducted with the new computed variables comparing the two gender groups. In this way it could be ascertained whether there was any significant difference between boys and girls regarding the changes in intrinsic motivation, extrinsic motivation and basic psychological needs or not.

The Impact of Hand Puppets on the Intrinsic and Extrinsic Motivation, and Basic Psychological Needs of Different Age Groups

The study investigated if age made any significant difference in predicting the intrinsic motivation, extrinsic motivation, and the basic psychological needs in terms of science learning after the use of hand puppets. To get a more extensive idea, a correlation was calculated between age and every variable in the pre- and post-tests. In addition to this, a MANCOVA was conducted where intrinsic motivation, extrinsic motivation and the basic psychological needs were the dependent variables, school, grade and gender were the fixed factors, and age was the covariate. The fixed factors were factored into the analyses as controlled variables.

Results

The Impact of Hand Puppets on Intrinsic and Extrinsic Motivation, and Basic Psychological Needs

For all the statistical tests we used an alpha level of 0.05. As stated in the data analysis section, we compared the means for the pre- and post-tests. The mean for intrinsic motivation in the pre-test was 2.28 ($SD = .63$) and for the post-test 2.73 ($SD = .46$). The difference between these two means was 0.45. Then, a paired sample t-test was conducted, but beforehand, we checked if the assumption of normality was met. A Kolmogorov–Smirnov test was done which showed that only the items of basic psychological needs were normally distributed: $D(88) = 0.07, p = 0.200$. The intrinsic motivation ($D(88) = 0.17, p < 0.001$) and extrinsic motivation ($D(88) = 0.10, p = 0.019$) were both significantly but not normally distributed. Because the sample size was larger than 30, a parametric test could still be conducted since the data relied on the central limit theorem. This allowed the study team to observe that the difference between the intrinsic motivation in the pre-test and the post-test was significant: $t(87) = 7.35, p < 0.001, r = .62$. Looking at the variance, we observed that the level of intrinsic motivation in the pre-test ranged from 0.50 to 3.00 and for the post-test from 0.75 to 3.00. The same steps were followed for extrinsic motivation. The mean for extrinsic motivation in the pre-test ($M = 1.59; SD = .84$) and the post-test ($M = 1.20; SD = 1.04$) was looked at, and a paired sample t-test was run; the observed difference of -0.38 was significant: $t(87) = -3.61, p < 0.001, r = .36$. For the basic psychological needs, the mean was 1.91 ($SD = .31$) for the pre-test and 2.36 ($SD = .40$) after the intervention. The 0.45 difference was significant as shown by the paired sample t-test: $t(87) = 10.60, p < 0.001, r = .75$. The variance showed that at the time of the pre-test, the level of basic psychological needs ranged from 1.12 to 2.67. With the post-test, this variance ranged from 1.44 to 3.00 (see Table 2 below for a summary of the means).

Table 2: The mean and standard deviations for the basic psychological needs, intrinsic and extrinsic motivation

		<i>M</i>	<i>SD</i>
Basic psychological needs	Pre-test	1.91	.31
	Post-test	2.36	.40
Intrinsic motivation	Pre-test	2.28	.63
	Post-test	2.73	.46
Extrinsic motivation	Pre-test	1.59	.84
	Post-test	1.20	1.04

After these analyses, a non-parametric, Wilcoxon signed-rank test was done for intrinsic and extrinsic motivation to see if the results pointed in the same direction. This was

important because the assumption of normality was not clearly met. The non-parametric test showed that the level of intrinsic motivation was significantly lower in the pre-test ($Mdn = 2.5$) than in the post-test ($Mdn = 3.00$): $T = 132.00$, $z = -6.11$, $p < 0.001$, $r = -.46$. For extrinsic motivation, the pre-test ($Mdn = 1.67$) result was significantly higher than the post-test result ($Mdn = 1.00$): $T = 695.00$, $z = -3.36$, $p < 0.001$, $r = -.25$.

The Impact of Hand Puppets on the Intrinsic and Extrinsic Motivation, and Basic Psychological Needs of Boys and Girls

An independent t-test showed that for girls, the mean of the difference of intrinsic motivation for the pre- and post-test was 0.40 ($SD = .53$) and for boys it was 0.52 ($SD = .64$). The mean difference ($M = 0.12$, $SD = .12$) between boys and girls was not significant: $t(86) = 0.93$, $p = 0.177$, $r = .10$. For extrinsic motivation the same steps were repeated. The mean difference for girls ($M = -0.49$, $SD = 1.03$) and boys ($M = -0.25$, $SD = .96$) is 0.25 ($SD = .21$) was also not significant: $t(86) = 1.15$, $p = 0.127$, $r = .12$. For the basic psychological needs the mean of the difference between the pre- and post-tests for girls was 0.50 ($SD = .34$) and for boys this was 0.38 ($SD = .46$). Because the Levene's test was not significant, the study looked at the t-test when equal variances were not assumed. The mean difference ($M = 0.12$, $SD = .09$) for this variable was also not significant: $t(68.54) = 1.43$, $p = 0.080$, $r = .15$.

The Impact of Hand Puppets on the Intrinsic and Extrinsic Motivation, and Basic Psychological Needs of Different Age Groups

There were no significant correlations between age and basic psychological needs ($r = -.02$, $p = 0.888$), intrinsic motivation ($r = .08$, $p = 0.470$) and extrinsic motivation ($r = -.04$, $p = 0.690$). Moreover, the MANCOVA led to the result that there is no significant effect of age difference on either the basic psychological needs or the intrinsic and extrinsic motivation: $\Lambda = 0.99$, $F(3, 81) = 0.32$, $p = 0.814$.

Discussion

The Impact of Hand Puppets on Intrinsic and Extrinsic Motivation, and Basic Psychological Needs

The paired sample t-test confirmed the positive impact of hand puppets on the intrinsic motivation of learners. Regarding intrinsic motivation, the range of the variance of the post-test became smaller, from a minimum of 0.50 in the pre-test to a minimum of 0.75 in the post-test. The maximum remained the same. This means that the learners were less likely to score a zero for intrinsic motivation items on the post-test compared to the pre-test. In summary, intrinsic motivation increased during the intervention. This is in line with the findings of Stuyvaert (2010) who stated that learners are more intrinsically motivated when puppets are used in the classroom. Additional evidence can be found in the following statements of the learners:

Science is more interesting because now I know and understand more about science.

Now I like science and I didn't liked it before. Now I just love it. I don't know how to explain it.

I like science very very much. Before I didn't [like it], but now I can see that science is very important.

In relation to extrinsic motivation, a decrease was expected and found. The mean dropped significantly to 0.38 on a range from zero to three. This implies that the learners on average were less extrinsically motivated at the end of the intervention. This confirms our hypothesis that extrinsic motivation would decrease, because this type of motivation (Gagne and Deci 2005) was not encouraged during the intervention. It also matches the purpose of the study to diminish extrinsic motivation because this type of motivation undermines intrinsic motivation (Deci, Koestner, and Ryan 2001). In addition, for both intrinsic and extrinsic motivation, the Wilcoxon signed-rank test affirms that there is respectively a significant increase and decrease between the pre- and the post-test.

With regard to the basic psychological needs, the study expected these to rise. With a 0.45 significant difference, the mean rose from 1.91 in the pre-test to 2.36 in the post-test on a range from zero to three. This means that the basic psychological needs of the learners were on average more fulfilled at the end of the intervention. These results are in line with the hypothesis that these basic psychological needs would increase if the overall motivation increases when using hand puppets in the teaching of science (Hackling, Smith, and Murcia 2011; Keogh et al. 2006; Naylor et al. 2007a; 2007b; Simon et al. 2008), and if pedagogical principles and teaching methods (Gallenstein 2005; Pintrich 2003; Urdan and Schoenfelder 2006) are used to support these needs. Furthermore, the following statements from a student about the basic psychological need of autonomy gives this hypothesis even more credibility: "Yes, I'm better than before, because I understand it better now. Because this book can explain me things I don't know."

The Impact of Hand Puppets on the Intrinsic and Extrinsic Motivation, and Basic Psychological Needs of Boys and Girls

The independent t-test shows that there were no gender-based differences detected in the motivational change in relation to science learning when using hand puppets. This means that the use of hand puppets is equally effective for both boys and girls to raise their motivation to learn science. This is a promising result, because girls have generally less positive attitudes towards science than boys (Osborne, Simon, and Collins 2003). Additionally, significant gender-based differences remain in science experiences, attitudes, and perceptions of science courses and careers (Jones, Howe, and Rua 2000). Hand puppets may be a solution to this problem and have a significant impact on the motivation of both boys and girls.

The Impact of Hand Puppets on the Intrinsic and Extrinsic Motivation, and Basic Psychological Needs of Different Age Groups

This study found evidence for the hypothesis that age has no significant impact on the motivation to learn science when using hand puppets. The age groups in this intervention ranged between the ages of 11 and 16 years. Consequently, it can be stated that hand puppets are equally effective for different age groups. This is consistent with other studies (Keogh et al. 2006; Stuyvaert 2010) and the following statement by the science teacher involved in the project: “I think it’s for all ages. That’s why, when the time is up, all of them stand up to pick up the puppets. I see they enjoy them.”

Limitations and Suggestions

Although significant results were found, it is important to mention three weaknesses in this study. First, the reliability of the scales applied to extrinsic and intrinsic motivation and basic psychological needs was low. This means that the items used in the questionnaire were not sufficient to really measure the intended motivational constructs. Therefore, caution is needed when interpreting the results. Because of this low reliability, the basic psychological needs are measured as one construct instead of three separate constructs. From the results obtained, it is therefore impossible to detect how the components have changed independently. It is suggested that further research is needed to examine these three basic psychological needs, with either a different questionnaire or other data gathering methods. A possible cause for the low reliability is the method of the questionnaire itself. The questionnaire might not be the best method of testing the motivation in South African primary schools, especially in communities where English is not the first language. To overcome this weakness, it is recommended that a translated version in learners’ home language be used or to measure the components of motivation in a qualitative way by means of interviews, observations, focus groups, and so forth.

A second limitation of this study is the lack of a control group. Hence, the study does not meet the requirements of an experimental design, but a quasi-experimental design. Consequently, it cannot be said with certainty whether the puppets or other variables affected the motivation of the learners. It is also difficult to exclude the factors that played a role in the motivational change of the learners.

Third, the intervention only lasted for seven weeks, which is a relatively short period to measure the long-term effects of the puppets on learners’ motivational change. Attitudes in general, and more specifically motivational aspects, are known to be structures in long-term memory (Tourangeau and Rasinski 1988), and are therefore difficult to change in a short period of time. It is possible that the motivational attitudes of the learners measured over a longer term would be different from the measurements immediately after the intervention. Longitudinal research may provide a solution to this problem.

In general, it can be assumed that the results obtained are relative and need to be interpreted with caution. Further research in the form of an experimental longitudinal design and other ways to test the motivation of the learners is recommended in this context. More importantly, issues to be explored in future research could include analysis of using hand puppets in the science classroom in multiple countries to compare the cross-country effectiveness.

Conclusions

First, in accordance with expectations, the intrinsic motivation and basic psychological needs of all the learners significantly increased and the extrinsic motivation decreased after the use of hand puppets in science teaching. This correlates well with other researchers who also found that the engagement and interest of learners towards science changed with the use of puppets in the classroom (Simon et al. 2008). With regard to gender and age, no differences were found, which indicates that hand puppets can be effective for both boys and girls and for different age groups.

According to Zuljevic (2005), the use of puppets in the classroom can be linked to Vygotsky's theory of the importance of play for a child's development in that puppets bring an element of play and dialogue into the classroom. She also linked the use of puppets to a relaxed atmosphere in the classroom where learners can relax, take the focus off themselves and pay attention to the main business, learning science. Furthermore, this is in line with Gagne and Deci's (2005) definition of intrinsic motivation, which could be directly transferred to puppets as agents of spontaneous satisfaction for learners because of their inherent intrigue.

Gagne and Deci (2005, 331) define intrinsic motivation as "an activity from which people get spontaneous satisfaction because they find it intriguing." People who are intrinsically motivated do things for their own sake, for example, because they experience joy, satisfaction or pleasure by carrying out a task. There is no need for rewards or constraints, and this is the big difference between intrinsic and extrinsic motivation.

These significant results can be interpreted in the light of hand puppets as a promising teaching method that positively affects the learners' motivation to learn science.

Implications for the Field

As puppets introduce dialogue or discourse in the classroom, children do not feel threatened to speak to the puppet as they sometimes feel in South African classrooms. Puppets have great potential for the teaching of science, particularly scientific discourse, as well as the acquisition of English as a learner's second language. Also resulting from the use of puppets would be learners that are intrinsically motivated to learn science, which would in turn result in more learners taking scientific subjects in higher grades.

Puppets can be used fruitfully as a curriculum teaching tool as well as to encourage discourse and heighten the motivation for science learning in school learners.

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