TRAINING TEACHERS TO PROMOTE TALENT DEVELOPMENT IN SCIENCE STUDENTS

Ton van der Valk[1]
[1] Freudenthal Institute for science and mathematics education (FIsme), Utrecht University, the Netherlands

Abstract: In recent years, the interest of governments and schools in challenging gifted and talented (G+T) science students has grown (Taber, 2007). In the Netherlands, the government promotes developing science programmes for talented secondary science students. This causes a need for training teachers, but what should an effective professional development programme about promoting talent development look like?

Junior College Utrecht (JCU), a cooperation of Utrecht University and 28 secondary schools (van der Valk & Pilot, 2012), has developed such a course in a design-based research. It is based on important objectives for promoting excellence in science education, including the key components of honours teaching approaches (Wolfensberger, 2012) and on characteristics of effective professional development programmes (pdp). The course was implemented and evaluated in two phases. The first phase resulted in a scenario for dissemination. During the second phase, the pdp was implemented in two institutions.

The effectiveness of the pdp was investigated using a questionnaire that was conducted at the end of the course. The main criteria for effectiveness were (1) the participants' appreciation of the course and (2) having attained the pdp objectives as well as the participants' personal objectives. Moreover, being a *learning teacher* was investigated as being a factor that promotes the effectiveness of the pdp.

Results showed that the pdp was effective in reaching its objectives and in the participants' personal objectives. The more teachers considered themselves to be a *learning teacher*, the more they had learned an appreciated the professional development programme.

Keywords: gifted and talented students; science teachers; professionalization; excellence.

INTRODUCTION

In nearly all secondary science classes, there are students that are willing and able to handle greater challenges than the standard school curriculum and teaching can offer them. In the last decades, increasing efforts have been made to promote talent development and excellence in education at primary, secondary and tertiary level (Heller, Mönks, Sternberg & Subotnik, 2002). However, many schools and teachers are not very well equipped to meet the needs of these students. As a result students may get bored and unmotivated for learning e.g. science. Because of an impending shortage of well-educated science workers, talent promotion is needed in science education in particular (Taber, 2007). In this, the teacher is the key stakeholder. Since promoting talent development is hardly included in the initial teacher education programmes, there is a need for professionalization of in-service teachers.

In recent years, interest of governments and schools in challenging the most talented students has grown. In the Netherlands, schools and universities are stimulated to pay more attention to talented students. Since 2004, Utrecht University (UU) cooperates with 28 secondary schools in the field of talent development in science students: Junior College Utrecht (JCU). JCU has a student as well as a teacher programme. In the student programme, selected students follow a science programme on the UU-campus, two days a week. Since 2011, JCU partner schools started programmes for talented science students in the schools as well. This raised a need to train their science teachers. This is also part of the JCU-teacher programme. The goal of this study is to design and investigate a professional development programme (pdp) that effectively prepares science teachers for to promote talent development in their classes and schools.

Theoretical Framework

Wolfensberger (2012) identified key components of honours teachers and of honours teaching approaches in tertiary education. She identified three main aspects of university honours teachers' dispositions, attitudes and beliefs: (1) their conceptions of teaching; (2) their motivation; (3) their perception of honours students. She also formulated three key components of honours teaching approaches: (1) creating community; (2) enhancing academic competence and (3) offering freedom. Studying effective learning for gifted and talented upper secondary science students, Van der Valk and Pilot, (2012) identified seven 'characteristics of a learning environment adapted to talent development'.

The general aspects of an effective professional development course (pdp) for teachers are: focus on (pedagogical) content knowledge, active and inquisitive learning, exchange of ideas with colleagues; concrete examples based on good practices, connected with school policy, a 'learning school' culture (van Veen *et al.* 2010; Loucks-Horsley, 1999). Developing this culture is promoted when the course members form a *community of practice* (Wenger 1998), e.g. by exchanging experiences. For implementing theory into practice, the congruence principle (Korthagen *et al.* 2001) says that teacher educators should treat teachers in the same ways they expect teachers to treat their students ('practise what you preach').

De Jong *et al.* (1998) found that an effective pdp for science teachers should provide strong relations between course activities and teaching activities, meaning, among others, providing practical examples from science classes.

Design-based research to the pdp

Based on this theoretical framework, a science teacher professional development programme was designed. The content of the pdp included topics like 'what is excellence', 'how to recognize gifted and talented (G+T) science students', how to implement the key components of honours education (Wolfensberger 2012) in science classrooms?' Also, many practical topics were addressed, like starting talent development trajectories in the school, involving colleagues and motivating the talented students. Moreover, concrete examples of differentiation in science classes were discussed. Following the congruence principle, the key components of G+T teaching approaches were not only part of the pdp learning goals, but were also present in the pdp pedagogy itself. The pdp demanded 120 hours of work for participants and was taught by experienced teacher educators/ course developers. All participants were volunteers, and supported by their schools. Course members were asked to read literature, test ideas they learned during the course and report about experiences.

The pdp was taught the first time in 2011/12 to a group of 25 science teachers from the JCU school network (the *U2012* group). The meetings were observed and evaluated and a final evaluation was carried out. Reflection on the experiences resulted in a scenario for dissemination. In the 2013/2013 course, the pdp was taught in two different institutions: Utrecht University (group U2013) and Eindhoven Technical University (group E2013).

The research questions of this study were: What is the effectiveness of this professional development course? What factors can influence its effectiveness?

Methods

Multiple methods were used, qualitative as well as quantitative. During the course observations were made by an independent observer. Written reports of experiences from the school and the classrooms were analysed. Here, we report the results of the questionnaire that was administered at the end of the course.

Instrument construction: questionnaire

The questionnaire focused on the participants' perception of the pdp, on attaining the pdp objectives as the main variables for effectiveness of the pdp and on being a learning teacher as a factor that might influence the effectiveness of the pdp. The *perception variables* were: appreciation, instructiveness and grading. The *objectives attained* variables were ' (1) pdp objectives attained; (2) honours teaching approaches; (3) pdp activities done at school.

In Section 1 ('about you'), personal data of the course participants were asked, such as gender, the subjects they taught in school and the number of years of experience in teaching.

Section 2 ('Course objectives') consisted of three parts: (2.1) nine 5-point Likert scale questions about pdp objectives attained; (2.2) three 5-point Likert scale items on instructiveness; (2.3) two open items, one about unexpected objectives attained; the final part was about personal objectives that were not attained. Examples of items from each part are shown in Figure 1.

Part 2.1: pdp objectives attained

At the end of the course, I know different ways
to realise differentiated education in my school. Not 1 2 3 4 5 fully attained

Part 2.2: instructiveness
To what extent has your knowledge about talent
development increased by this course? Hardly 1 2 3 4 5 to a high degree

Part 2.3: open answer questions on objectives (not) attained:

Which of your own objectives was not attained?
…………………………………………………………………….

Figure 1: Example items from section 2

By the part 2.1 items on pdp objectives attained, the respondents were asked to indicate to what extent (1 = not at all; 5 = completely) they have attained the main objectives of the pdp, in their own perception (construct ‘objectives attained’). Objectives mentioned in the items were, among others: developing a vision on promoting excellence in the school; knowing the characteristics of a talent development adapted learning environment (Van der Valk & Pilot, 2012) and being able to advise colleagues and principals about promoting excellence.

Part 2.2 consists of three likert items of the same kind as in part 2.1, on instructiveness. The respondents were asked to indicate to what extent they have learned from the course.

By the open items of part 2.3, the respondents were invited to mention objectives attained, that they did not expect beforehand, as well as personal objectives that were not attained.

Section 3 (‘the pdp in general’) consists of three parts. Part 3.1 consists of one question: to give the course a grade on a 1 (very poor) to 10 scale (excellent). This kind of grading is common in Dutch education for tests. Part 3.2 consists of ten 5-point Likert scale items on appreciation of the course (‘appreciation’). See Figure 2 for an example item. Part 3.3 consisted of an open question, asking for ‘three things you will implement at school, related to this course’.

Part 3.2							
I found the course	*not challenging at all*	*1*	*2*	*3*	*4*	*5*	*very much challenging*

Figure 2: Example item from section 3, part 3.2

Section 4 (‘teaching your talented students’) was added to the 2013 questionnaire. It consists of two parts. See Figure 3 for example items. By part 4.1 the honours teaching approaches (Wolfensberger, 2012) were operationalized. Each component (community of learners; academic competencies; structured freedom) was measured by five sets of two items. Each set consists of a statement about which the participant is asked to tick the importance and the mastering. These items are borrowed from Kazemier (2013) and adapted to the secondary school context. The ten items of part 4.2 are on ‘the learning teacher’. They are also borrowed from Kazemier and have the same structure as the part 4.1 questions.

Part 4.1: honours teaching approaches					
I give my talented students room for choices about content and approach					
Importance	*very low 1*	*2*	*3*	*4*	*5 very high*
Mastering	*very low 1*	*2*	*3*	*4*	*5 very high*
Part 4.2: the learning teacher					
I use feedback and ideas from students and colleagues for my own development					
Importance	*very low 1*	*2*	*3*	*4*	*5 very high*
Mastering	*very low 1*	*2*	*3*	*4*	*5 very high*

Figure 3: Example items from section 4

Data collection and response

The questionnaire was administered electronically at the end of the last pdp meeting. It was completed by the U2012 (questionnaire version without part 4), the U2013 and the E2013 participants. The teachers of the U2012 and U2013 groups were the designers of the course from Utrecht University. The teachers of the E2013 group were experienced science teacher educators from Eindhoven Technical University. Table 1 shows that the responses to the questionnaire were quite high.

Table 1
The responses to the questionnaire

	U2012 course	*U2013 course*	*E2013 course*	*total*
completed questionnaires	17	18	14	49
number of course participants	25	19	18	62
response	68%	95%	78%	79%

There were 59% male respondents; 41% female. All taught science or mathematics in secondary school and were interested in excellence and developing the science talents of their able students. Most participants had more than 5 years of experience with science teaching (see Table 2). There were no main differences between the three groups in gender, subjects taught or years of experience.

Table 2
Years of experience as a science teacher

N=49	*number*	*%*
0 – 2 years	2	4
3 – 5 years	5	10
5 – 10 years	13	26
> 10 years	29	59

Processing the data

In Table 3, the reliabilities of the constructs are presented. It shows that the scales and sub-scales had sufficient to good reliabilities.

Table 3
Reliability of scales

scale	*N*	*number of items*	*Cronbach's α*
objectives attained	49	9	.69
instructiveness	49	3	.64
appreciation	49	13	.87
honours teaching approaches	32	30	.80
a. importance		*15*	*.82*
b. mastering		*15*	*.76*
the learning teacher	49	10	.84
a. importance		*5*	*.78*
b. mastering		*5*	*.75*

Confirmative factor analysis of 'honours teaching approaches' did not produce the three expected components of 'honours teaching approaches' ('structured freedom', 'academic competences' and 'community of learners'). An explorative factor analysis did not result in meaningful constructs.

The quantitative data were processed using SPSS. Mean values and standard deviations were computed. Paired t-tests, independent t-tests and Pearson correlations between scales were computed.

In the answers to the part 2.2 open questions, the number of different 'additional objectives attained' and of the 'personal objectives not attained' were counted. The

answers to the part 3.3 open question were categorised in four categories of activities (see Figure 4 for an example):
1. focus on talented or excellent students
2. cooperating with or empowering (science/mathematics) colleagues
3. planning or carrying out activities, learnt in the course, in the classroom
4. (contacting the school management about) programmes for talented students on school level.

To each category, a number was attributed being zero if the category was empty and being 1 if the category was filled with one of more activities. So, the variable 'activities at school' was constructed, having a integer value between 0 and 4 and consisting of the 'activity' components 'talent development', 'classroom', 'colleagues' and 'principals'.

Participant answer: *I have contributed to a programme for excellent grade-9 students. I gave them more differentiated tasks.*
Categorisation:
Category 1: *excellent students*
Category 3: *differentiated tasks*

Figure 4. An example of categorisation of a part 4.4 open answer

The categorisation was done by two raters independent from each other. The interrater reliability was calculated by dividing the number of differently categorised (parts of) statements by the total number of statements categorised. The results show that the interrater reliabilities were fairly good (Table 4).

Table 4
Interrater reliability

open question from questionnaire	*topic*	*value*	*number of statements*
section 2, part 3a	additional objectives attained	.87	82
section 2, part 3b	personal objectives not attained	.89	46
section 4, part 4	quality of activities at school	.80	119

After the independent categorisation, the raters met and discussed the categorisation of the answers they disagreed upon, until agreement. The values agreed upon were added to the database.

Results

Pdp perception variables

Participants' perception of the professional development programme (pdp) were measured by the scales 'appreciation', instructiveness' and by the 'grading' the participants gave to the pdp. Results are shown in Table 5.

Table 5
Mean scores of pdp perception variables

	range	*N*	*Mean*	*SD*
appreciation	1 – 5	49	3.91	0.49
instructiveness	1 – 5	49	4.01	0.54
grading	1 - 10	49	7.90	0.85

The variables appreciation, instructiveness and grading highly correlated (see Table 6). This shows that all three contributed to a similar perception of the pdp, that we interpret as the feelings towards the pdp.

Table 6
Correlation between pdp perception variables

	Grading	*Appreciation*
Appreciation	.961**	
Instructiveness	.731**	.672**

** significant on level *p*<.01

It is concluded that participants feelings about the pdp were positive.

Objectives attained

In Table 7 the results of the quantitative data are listed.

Table 7
Results 'objectives obtained'

Scale	*N*	*M*	*SD*
Pdp objectives attained	49	3.97	.43
honours teaching approaches	32	3.96	.28
Importance teaching approaches	32	4.23	.38
Mastering teaching approaches	32	3.69	.35

Table 7 shows that the participants found that they had attained the pdp objectives to a considerable degree. Table 7 also shows that the U2013 and E2013 groups found the honours teaching approaches very important and that they felt they mastered these approaches to an intermediate extend. The mean score for the Importance component is significantly higher ($t(32) = 6.40$, $p<.001$) than the Mastering component, with a big effect ($r = 0.75$). The analysis of the qualitative data showed that the participants named quite some objectives ($M = 1.59$) they had attained additional to the pdp objectives, e.g. *I gave advises to my colleagues and my principal.* The respondents named quite some 'activities at school' they implemented as a result of the pdp. The mean value of the variable *activities at school* was 2.43. Table 8 shown the distribution among the four categories.

Table 8
Activities at school

Categories	*M*
Talent development	.84
Classroom	.78
Colleagues	.57
Principals	.24

'Honours teaching approaches' correlates moderately with 'objectives attained' ($r(32) = .356$, $p<.05$). The variable 'activities at school' show a moderate correlation with mastering honours teaching approaches ($p = .353$*). Surprisingly, the importance and mastering honours teaching approaches components do not correlate with each other. So the 'objectives attained' variables show only a few correlations.

The variable ‘pdp objectives attained’ correlated rather strongly with the pdp perception variables ‘appreciation’ (.556**), ‘instructiveness’ (.542**) and ‘grading’ (.413**), suggesting that appreciating the pdp is connected to attaining the pdp objectives.

It is concluded that the respondents found that the pdp objectives, their personal objectives and the honours teaching approaches objectives were attained to a large extent.

The learning teacher

The values for the learning teacher are given in Table 9. This shows that the respondents found being a learning teacher very important and that they mastered it to a large extent. However, the mean score for importance is higher ($t(32) = 5.86$, $p < .001$) than the score for mastering, which is a big effect ($r = 0.72$). Importance and mastering correlate significantly ($r(32)=.660$; $p=.000$).

Table 9
Results ‘the learning teacher’

Scale	*N*	*M*	*SD*
The learning teacher	32	4.21	.42
Importance	32	4.40	.43
Mastering	32	4.01	.48

‘Mastering learning teacher’ correlated with ‘objectives attained’, $r(32)=.361$, $p<.05$. Furthermore, ‘importance learning teacher’ correlates strongly with ‘importance honours teaching approaches’ ($r(32)=.643$, $p=.000$). ‘Mastering learning teacher’ correlates rather strongly with ‘mastering honours teaching approaches’, (r(32)=.471, p<.01).

It is concluded that the respondents found being a learning teacher very important and, coheringy, considered themselves being a learning teacher. Correlations suggest that considering oneself as a learning teacher is connected with mastering honours teaching approaches and attaining pdp objectives.

Conclusions and implications

The pdp on promoting excellence in science education was effective in being appreciated by the participants and in attaining its objectives as well as participants’ personal objectives. A main aspect was the use of *good practices*, in particular exchanging the good practices that already were present in the schools. This seems to foster the mastering of honours teaching approaches. The correlations between ‘learning teacher’ and ‘objectives attained’ suggest that the pdp is in particular effective to participants who regard themselves as a learning teacher. Moreover, the optimal participant for the pdp is a teacher from a school that is currently organizing or that has already organized a talent development programme in the school.

We conclude that the pdp is good enough and that no redesign is needed. Nevertheless, participants suggest some points of attention, such as ‘keep close to the teaching practice in the schools and show as many concrete *good practices* of promoting excellence in science classes as possible.

As the participants appreciated being a member of a community during the pdp, some additional characteristics of ‘effective pdp’ (Van Veen, 2011) can be: bring like-minded teachers, sharing the similar aims, from different schools together in a pdp. If *good practices* can be borrowed from these schools, an emotional bond with these promotes applying it in the own classrooms.

It is recommended to investigate the results of the pdp for school and classroom practice: does promoting excellence in science work for the students and what does this mean for the development of talented students? First steps in implementing the pdp nationwide in the Netherlands have been made and more are to follow. Probably, the implementation can also be done on a European scale.

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REFERENCES

De Jong, O., Korthagen, F. & Wubbels, T. (1998). Research on science teacher education in Europe: teacher thinking and conceptual change. In B. Frazer & K. G. Tobin (Eds.) *International Handbook of Science Education* (pp. 745-758). Dordrecht/Boston: Kluwer Academic Publishers.

Heller, K.A., Mönks, F.J., Sernberg, R.J., & Subotnik, R.F. (2000). *International Handbook of giftedness and talent. 2nd edition.* Oxford: Elsevier Science.

Korthagen, F. J. (ed.) (2001). *Linking Practice and Theory: The Pedagogy of Realistic Teacher Education.* Mahwah, NJ: Lawrence Erlbaum Associates.

Loucks-Horsley, S., E. Stiles, K.E., Mundry, S., Love, N., Hewson, P.W. (2010). Designing Professional Development for Teachers of Science and Mathematics. Thousand Oaks, California: Corwin (Sage).

Taber, S.T. (ed.) (2007). *Science education for gifted learners*. London and New York: Routledge.

Valk, T. van der, & Pilot, A. (2012). Empowerment and heterogeneity among talented pre-university science students in an enriched learning environment. In S. Markic, I. Eilks, di Fuccia, D., & B. Ralle (Eds.): *Issues of Heterogeneity and Cultural Diversity in Science Education and Science Education Research*. Aachen: Shaker Publishing 978-3-8440-1599-7. p.133-142.

Van Veen, K., Zwart, R., Meirink, J. & Verloop, N. (2010). *Professionele ontwikkeling van leraren. Een reviewstudie naar effectieve kenmerken van professionaliseringsinterventies van leraren. (professional development of teachers. A review study to effective characteristics of teacher professionalisation interventions.*) Leiden University: ICLON.

Wenger, E. (1998). *Communities of practice: learning, meaning, and identity.* Cambridge: Cambridge University Press.

Wolfensberger. M.V.C. (2012). *Teaching for excellence. Honors pedagogies revealed*. Münster: Waxmann.