MOTIVATIONAL ORIENTATIONS IN PHYSICS LEARNING: A SELF-DETERMINATION THEORY APPROACH

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Introduction

Since the 1960s onwards student motivation and attitudes ('student voice') towards physics learning has been actively studied (for a review, see Osborne, Simon & Collins, 2003). However, relatively few studies have a clear and consistent theoretical orientation which connects the problems of physics learning to a broader theoretical framework of motivation. Moreover, the structure of female and male students' motivation to learn physics has been seldom discussed and systematically analysed, although several studies have shown that male and female students have many differences in their motivation to learn physics (see e.g., Lavonen, Byman, Juuti, Meisalo & Uitto, 2005; Stokking, 2000).

In the present study, the conceptualisation of motivation is based on the theory proposed by Edward Deci and Richard Ryan. This theory is called the Self-Determination Theory (SDT). Central to SDT is the concept of basic psychological needs that are assumed to be innate and universal. These needs are the need for *competence*, the need for *autonomy*, and the need for *relatedness*. According to Ryan and Deci (2002), motivation is a process in which a person's way of thinking has an important role. Motivated behaviour may be *self-determined* or *controlled*. These two types of motivated behaviour involve different reasons for behaving. By self-determined or autonomous behaviour, Deci and Ryan (1985) meant freely chosen behaviour which arises from one's self. To be autonomous means to study with a full sense of volition because the studying itself is interesting or personally important. Controlled behaviour, in contrast, means that the behaviour is "controlled by some interpersonal or intrapsychic force" (Deci, Vallerand, Pelletier, & Ryan, 1991, p. 326). This means that a person has a feeling of pressure, that is, he or she has a "should do" or a "must do" feeling.

Ryan and Deci (2002) have suggested that two primary cognitive processes affect motivation. They are a change in the *perceived locus of causality* and a change in *perceived competence*. When the

Abstract. *The first objective of the present study was to test the factorial validity of the inventory designed to measure students' motivation to study physics in school. Based on self-determination theory (SDT), it was hypothesised that the four factors of External Regulation, Introjected Regulation, Identified Regulation and Intrinsic Motivation account for the covariances among the items of the inventory. It was also expected that gender moderates the factorial validity of the inventory. A sample of 3626 Finnish comprehensive school students was used. A multilevel confirmatory factor analysis (MLCFA) was used to investigate the fit of the hypothesised four-factor model. The second objective of the present study was to investigate different educational correlates of the four motivation factors. Girls had a statistically higher mean score than did boys for all four factors. Otherwise only minor gender differences were found. Implications for physics teaching are discussed.*

Key words: *motivational orientations, multilevel confirmatory factor analysis, science learning, self-determination theory.*

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perceived locus of causality changes toward a more internally perceived locus, the intrinsic motivation or the more self-determined forms of extrinsic motivation will be enhanced. When students are extrinsically motivated, they perceive the locus of causality and the regulation of their studying activities to be external to themselves, whereas when students are intrinsically motivated they perceive the locus to be within themselves. Change in perceived competence is related to the psychological need for competence. Events that increase perceived competence enhance intrinsic motivation, whereas events which reduce perceived competence tend to undermine intrinsic motivation.

According to Ryan and Deci (2000, p. 70), intrinsic motivation can be described as an "inherent tendency to seek out novelty, and challenges, to extend and exercise one's capacities, to explore and to learn." Intrinsically motivated behaviour is characterised by concentration and engagement; it occurs spontaneously and people become wholly absorbed in it. Emotions, such as "interest", "excitement," and "enjoyment" are distinctive marks of intrinsically motivated activity. Intrinsically motivated behaviours are based on the need to feel competent and self-determined. Moreover, teachers who support autonomy have been shown to have more intrinsically motivated students with higher levels of self-esteem, compared to the students of teachers who are control oriented (Deci, Nezlek, & Sheinman, 1981). Thus, providing choice rather than control and acknowledging students' inner experiences enhances intrinsic motivation and the students learning improves (Deci & Ryan, 2000). Vallerand, Pelletier, Blais, Brière, Senècal, and Vallières (1992) have split intrinsic motivation (IM) into three types: IM to know, IM to accomplish things, and to experience stimulation.

Several studies (see e.g., Deci, 1975; Deci & Ryan, 1985) have shown that intrinsic motivation has several positive effects on learning. However, it is unrealistic to imagine that all physics learning can be intrinsically motivated. That is, it is not possible to make all the goals of the curriculum intrinsically motivating, and in a classroom situation it is not always possible to give students choices about what they should learn (see Byman & Kansanen, 2008). Intrinsic and extrinsic motivation were first described as a dichotomy, and extrinsic motivation was even said to be disastrous to intrinsic motivation (Deci, 1975). However, later Deci and Ryan (1985) limited the idea of the antagonistic nature of intrinsic and extrinsic motivation. Through internalization process, extrinsically motivated behaviours can become increasingly self-determined or autonomous. When the internalization process succeeds, students will identify with the importance of the aims of the curriculum and will assimilate the aims into their integrated sense of self, and thus fully accept them as their own.

Self-determination theory draws distinctions between four types of extrinsic motivation based on how self-determined each type is, namely external, introjected, identified, and integrated forms of regulation. External and introjected regulation are considered to be relatively controlled forms of extrinsic motivation, whereas identified and integrated regulation are considered to be relatively autonomous.

External regulation refers to intentional behaviours that are performed to earn some expected reward or to avoid a threatened punishment. Externally regulated behaviours are the least self-determined behaviours because the underlying values have not been internalized. A student who does homework to avoid parental reproach is externally regulated. Working only if the teacher is in the area is also an example of this form of motivated studying. Externally regulated studying is expected to show poor maintenance and transfer once the teacher's control is withdrawn.

By *introjected regulation* Deci and Ryan (1985) meant studying activities that are motivated by internal prods and pressures that are connected to the student's self-esteem. The student can feel that he or she should do something or else suffer from negative feelings such as guilt. For example, student learning in small groups during practical work or projects can have a positive influence to student self-esteem and feelings. According to Deci and Ryan (2000, p. 236), "introjected represents a partial internalization in which regulations are in the person but have not really become part of the integrated set of motivations, cognitions, and affects that constitute the *self*. " Thus, introjected regulation is not self-determined. However, introjected regulations are expected to maintain over time better than totally externally regulated studying activities.

Identified regulation occurs when the regulation has become a part of the self. Thus, a student feels it to be personally important or valuable and participates in the studying activity more willingly. A student may, for example, be interested in a science-, technology- or engineering-related occupation. Therefore,

a physics teacher might support identified regulation if he or she acts as a kind of career counsellor. An appropriate context, for example, the science, technology or engineering context, or an activity such as a site visit might lead to this type of extrinsic motivation. In comparison to introjected regulation, identification makes it possible to feel a sense of choice or volition about studying. In identifying the value of a learning goal, students study more volitionally. An example would be a student who willingly does extra work in physics because the student believes it is important for continued success in that subject. The internalization has been more complete than with introjection, and this kind of studying becomes more a part of the student's identity. Studying that has a regulation based on identification is expected to be better maintained and to be associated with higher commitment and performance (Deci & Ryan, 2000).

The most self-determined form of extrinsic motivation is *integrated regulation,* which appears primarily in adult stages of development. The regulatory process is now fully integrated with the student's self and the student does the activity wholly volitionally. Integrated regulation results when "particular values and actions that one has identified with have been fully reconciled with one's other values and actions, as well as with one's organismic experience (Ryan et al., 1996, p. 12)." Integrated regulation resembles intrinsic motivation in that both are self-determined. However, they are not the same. Intrinsic motivation is characterised by interest in the studying activity itself, whereas integrated regulation is characterised by the activity's personal importance to a valued outcome. Integrated regulation, is supposed to have positive effects on learning similar to those of intrinsic motivation.

Research Objectives

The first research objective of the present study was to test the factorial validity of an inventory designed to measure students' motivation to study physics in school. Based on the SDT, it was hypothesised that the four factors of External Regulation, Introjected Regulation, Identified Regulation and Intrinsic Motivation would account for the covariances among the items of the inventory. According to SDT, regulation resulting from integration appears only in adult stages of development. Thus, the designed inventory did not include integrated regulation sub-scale (cf. Ryan & Connell, 1989).

The second research objective was to investigate different educational correlates of the four motivation factors. As Cronbach and Meehl (1955) first suggested, the nomological network of a construct is an important step in its construct validation. Some theoretical and empirical evidence suggests that intrinsic motivation and identified regulation of extrinsic motivation have a positive impact on school performance and attitudes to physic learning (see e.g., Koestner & Losier, 2002; Reeve & Jang, 2006; Vansteenkiste, Lens & Deci, 2006).

Regarding the educational correlates of the four motivational orientation factors, the present research focused on the relationship between teacher's style of teaching and the motivational orientation of their students. According to Deci and Ryan (2000, p. 238; see also Reeve, 2009), when teachers are "both autonomy supportive and involved, natural states of intrinsic motivation are less likely to be undermined, and the internalization and integration of extrinsically motivated behaviors will be facilitated." The study of Reeve and Jang (2006; see also Ryan & Deci, 2009) has confirmed that teacher's style of teaching and motivating students correlate with students' perceptions of autonomy. Such instructional behaviours as for instance listening to students, creating time for independent work, giving student opportunity to talk, and being responsive to the student's questions and experience correlated positively with students' perceptions of autonomy. Likewise, such instructional styles as monopolising the learning materials, physically and exhibiting worked-out solutions and answers before the student had time to work on the problem independently, directly telling the student a right answer instead of allowing the student time and opportunity to discover it, and using controlling questions as a way of directing the student's work correlated negatively with students' experience of autonomy. Thus, it was hypothesised that teacher's autonomy supportive motivating and teaching style correlates positively to intrinsic motivation and identified regulation of extrinsic motivation. Respectively, it was postulated that teacher's controlling teaching style had a negative correlation to intrinsic motivation and identified regulation of extrinsic motivation.

Previous studies (see e.g., Häussler & Hoffman, 2002; Kerger, Martin & Brunner, 2011) have shown that gender specific differences in motivation and achievement in physics exist. Physics is considered to be genuinely masculine. Being interested in physics may threaten the self-perception of girls as well as the femininity of their self-image. Thus, in the present study, it was also expected that gender would moderate the factorial validity of the inventory (see e.g., Carlson & Mulaik, 1993; Mulaik, 2010). There can be no valid comparison of the means for girls and boys if the measurement instrument is not invariant. As Hoyle and Smith (1994) have noted, the comparison of means when the measurement is non-invariant is like "comparing apples and oranges." A great deal of evidence from several studies (see e.g., Gilbert & Calvert, 2003; Häussler & Hoffman, 2002; Lavonen, Byman, Juuti, Meisalo & Uitto, 2005) indicates that boys and girls show both qualitative and quantitative differences in orientation to learning physics. However, before firm conclusions can be drawn about these gender differences, it is necessary to first confirm that the differences observed are not due to differently valid measuring instruments. For example, when a written instrument, such as a self-report inventory, is used, it is even likely that gender differences exist in understanding the meaning of the words and sentences that are used (Groves, 1989). The factorial validity of the developed scale was investigated both at the student and school levels.

Methodology of Research

Data Gathering

The data of the present study was gathered randomly for cluster sampling from the selected 75 schools from the list of Finnish-speaking comprehensive schools in Finland. A total of 4954 students were selected for the survey and 3626 students answered, which corresponds to 73% of the students in 81% of the selected schools. The survey data of 9th grade students were collected in spring 2003.

Questionnaire

The Physics Learning Orientation Scale (PLOS) used in the present study was based on the 32-item Academic Self-Regulation Questionnaire (SRQ-A) developed by Ryan and Connell (1989). The PLOS was modified to measure students' motivational orientations to study physics. For the PLOS, the items of the SRQ-A were modified and also new items to measure intrinsic motivation (INT) and three kinds of extrinsic motivation, namely external regulation, introjected regulation, and identified regulation was designed. A deductive approach (see e.g., Burisch, 1984) was used in constructing new items for the PLOS. To check the translation, techniques recommended by Brislin (1986) were used. The Finnish translations of the items were translated back into English by an outside expert and then compared to the original items. In the content validation process, the content of the inventory items was also evaluated to ensure that they represented and covered intended motivational orientations. Numerous revisions were made after this evaluation until a consensus about the item contents was obtained. The final inventory included 24 items (see Appendix A). The items were rated with a Likert-type scale that included four categories: *always, almost always, sometimes,* and *never*.

To research teachers motivating and teaching style (controlling or autonomy supportive) four items where used. These items (e.g., "Teacher takes account of the ideas and suggestions made by the students when the lesson is planned and implemented") based on the Learning Climate Questionnaire (LCQ) developed by Williams, Wiener, Markakis, Reeve and Deci (1994). For all these items students rated their teachers teaching style on a five point Likert-type scale *never – very often*. Performance in physics learning was measured with the last mark in physics (scale from 4 to 10) and attitude to physics learning with three items. The first attitude item was an item where students had to choose what is the most important subject in school (mathematics and mother tongue as "instrument subjects" where eliminated from the list). The other two attitude items were five point scales "Physics is unnecessary-important subject" and "Physics is unpleasant-pleasing subject".

Data Analyses

The data set of the present study had the classical hierarchical structure: scores are nested within students, and students are nested within schools. Hence, a two-level multilevel confirmatory factor analysis (MLCFA) was used to investigate the fit of the hypothetical model (Hox, 1995). The use of the MLCFA made it possible to simultaneously examine the factor structure at the school and student levels. In this kind of two-level analysis, the student level structure is often more complicated than that of the school level (see e.g., Kuhlemeier, Van den Bergh and Rijlaarsdam, 2002). Correlations of the between-student factor are interpreted in the same way as in a unilevel factor analysis whereas between-school correlations represent the relationships between the factor means of the schools. In the MLCFA, the total factor variance can be decomposed into a between-schools component and a between-student component. Thus, a relatively large between-schools component suggests that the measurement is strongly affected by classroom and school characteristics.

In the present study, the testing procedure at the student level started with the four-step logic suggested by Mulaik (2010). According to this view, testing should start from an unrestricted factor model, and then proceed to more restricted factor models. The first-step model tests whether the a priori postulated number of latent variables can account for the covariances among the observed variables (Mulaik & Millsap, 2000; see also Byman, 2005). All unrestricted models with the same number of factors will yield the same fit to the data. In the present study, the invariance of the factor structures across gender was tested at the student level through a sequence of nested multigroup models. Applying a suggestion by Byrne (1998; see also Martin & Marsh, 2006), the hypothesis-testing strategy of the present study was as follows:

Hypothesis I: Testing for the validity of factor structure (H_{form})
Hypothesis II: Testing for the invariance of factor loadings (H_{λ})
Hypothesis III: Testing for invariant factor variances and covariances ($H_{\lambda\phi}$)

Byrne et al. (1989; see also Byrne, 1998) have noted that most measuring instruments are actually only partially invariant across groups. Byrne et al. also demonstrated that a meaningful comparison of means is possible in situations where only partial measurement invariance is present. More recently, Steenkamp and Baumgartner (1998) have argued that comparisons of factor means are meaningful if at least one item (other than the reference item) is metrically invariant. By "metrical invariance" Steenkamp and Baumgartner meant the invariance of factor loadings (H_{λ}). Thus, the last invariance test of the present study was as follows:

Hypothesis IV: Testing for invariant factor mean structure ($H_{\lambda vK}$).

The different educational correlates (teachers teaching style, performance, attitude and importance) of the four motivation factors were investigated with zero and partial correlations. To control for collinearity of the educational correlates, partial correlations were conducted in which other correlates were included as covariates in the analysis (see e.g., Martin & Marsh, 2006).

Assessment of Model Fit

In the present study, three types of fit indices were used. First, the Satorra-Bentler scaled chi-square (S-Bχ^2) was used as an absolute fit indice. Second, the Incremental Fit Index (IFI) was used as a type 2 fit index. Third, the Comparative Fit Index (CFI) was utilised as a type 3 fit index. All three types of incremental fit indices are based on different rationales, and each describes somewhat different aspects of fit (see e.g., Hoyle & Panter, 1995).

In the present study, a conventional 0.90 cut-off or "rule of thumb" criterion for the IFI and CFI indices was used for restricted factor models. On the other hand, a value of at least 0.93 was expected in order for a model to be considered well-fitting (Byrne, 1994). Due to the fact that the unrestricted model is very liberal, it is important to have strong statistical support for it. Thus, following Mulaik and Millsap's (2000) suggestions, a 0.95 cut-off criterion for the CFI and IFI was used for unrestricted factor models. The Steiger-Lind Root Mean Square Error of Approximation (RMSEA) index was used to investigate how well individual models fit the statistical population. According to Browne and Cudeck (1993), a RMSEA

index value below 0.05 indicates a good fit. However, in practice, RMSEA values of about 0.08 or less indicate a reasonable error of approximation.

Results of Research

In the present study, the number of observations on the student level was 3626 (1794 girls and 1832 boys), while on the school level the number was only 68. Thus, it made sense to start the analysis on the student level (cf. Hox, 1995). However, before proceeding to the model testing phase estimates of internal consistency were calculated for all subscales used. The resulting alpha coefficients are presented in Table 1. The coefficients confirmed that all four scales are internally consistent.

The Within-Group Model

To test the hypothesis that four factors account for the observed covariances, an equivalent unrestricted factor model (Model 1u) was constructed for both gender groups. Following Jöreskog's (1979) suggestion, Item 14 was postulated to load only on Factor 1, Item 9 only on Factor 2, Item 23 only on Factor 3, and Item 21 only on Factor 4. These four reference variables were expected to be pure in their respective factors and very close to the meaning of the concept. Thus, each column of the factor pattern matrix contained three fixed values of 0 and one fixed value of 1. The other elements of the factor pattern matrix were estimated freely. The factor-covariance matrix contained factor variances in the diagonal. This model was tested simultaneously for both gender groups. As Table 2 shows, the statistical fit of Model 1u was very good for both gender groups.

Next a four-factor restricted CFA model was constructed. According to the conceptual model presented by Ryan and Connell (1989), four factors, namely External Regulation (EXT), Introjected Regulation (INTRO), Identified Regulation (ID), and Intrinsic Motivation (INT) were expected to reduce the data in both gender groups. As shown in Table 2, the goodness of

Table 1.   Alpha coefficients for the self-report inventories used.

	Sample	
Scale[a]	Girls	Boys
	(N=1614)	(N=1641)
EXT (5)	0.78	0.83
INTRO (6)	0.72	0.65
ID (6)	0.88	0.88
INT (7)	0.87	0.82

Table 2.   Goodness-of-fit statistics for the individual level models.

Model	df	S-Bχ2	CFI	IFI	RMSEA
Girls					
1 Model 1u	186	1573	0.98	0.98	0.067
2 Model 2	246	4158	0.93	0.93	0.099
3 Model 3	199	1792	0.97	0.97	0.070
Boys					
1 Model 1u	186	1073	0.99	0.99	0.054
2 Model 2	246	2813	0.97	0.97	0.080
3 Model 3	199	1508	0.98	0.98	0.063

fit for Model 2 was on an acceptable level for both girls and boys. However, a detailed inspection of the results showed that the model had discriminant validity problems in both gender groups. The ID and INT factors were highly correlated (φ_{Girls}=0.97 and φ_{Boys}=0.99), which suggests that these two latent variables may not be distinct constructs. To test the post hoc hypothesis that the two latent variables are not distinct, a method suggested by Schumacker and Lomax (1996) was used. The chi-square value of Model 2 was compared to the values of two restricted models in which the correlations between the problematic factors was fixed to value 1. The resulting $\Delta\chi^2$ was statistically significant for both gender groups thus indicating that the fixed model did not fit better than the original model, S-B$\Delta\chi^2(1)_{Girls}$=11.54, p<0.001 and S-B$\Delta\chi^2(1)_{Boys}$=11.83, p<0.001. This result meant that, although the correlation between ID and INT factors was high in both gender groups, the four-factor model did not completely reverted to a three-factor model.

The result that ID and INT factors almost collapsed into a single factor resembles the results presented by Norwich (1999). On the other hand, in the present study one reason for the collapse of the factors seemed to be wrong item specification. According to the Academic Self-Regulation Questionnaire (Ryan & Connell, 1989), Item 3 "I learn physics, because I want to learn new things" and Item 18 "I study physics, because I want to understand things in physics" should load on the ID factor and thus measure Identified Regulation. However, the results of both Model 1u and Model 2 showed that the students in the present study interpreted these items differently than they did in Ryan and Connelly's study. In the present study, Items 3 and 18 seemed to measure Intrinsic Motivation instead of Identified Regulation. There are also theoretical foundations for this change in relations between the latent and observed variables. Vallerand, Pelletier, Blais, Brière, Senècal, and Vallières (1992) split intrinsic motivation (IM) into three types: IM to know, IM to accomplish things, and IM to experience stimulation. The first type of IM, IM to know or IM knowledge refers to the "motivation for doing an activity for the feelings associated with exploring new ideas and developing knowledge (see Noels, Pelletier, Clément & Vallerand, 2003, p. 38)." Based on this interpretation of intrinsic motivation, it seemed reasonable that Items 3 and 18 of the present inventory measure INT instead of ID. Thus, the specification of these two items was changed to correspond to the interpretation held by Noels et al. After this change, a post hoc CFA model (Model 2a) was constructed where the correlation between the ID and INT factors was fixed to 0. In both gender groups the correlations among other factors were set free. Using the modification indices (MI) of this model, it was possible to find the two items which most increase the correlation between the ID and INT factors. These items were Items 13 and 22. Both these items had a high MI for the ID or the INT factor, MI_{Item13}=42 and MI_{Item22}=56. Moreover, Item 22 was also badly formulated and could have been interpreted in two ways. Thus, Items 13 and 22 were eliminated from the model. The results from Model 2 also show that a substantively meaningful error terms exist between Items 7 and 9. The most plausible explanation for this finding seemed to be the similarity in item wording. Byrne (1994), for instance, has argued that highly overlapping item content can lead to systematic error variance and correlating measurement errors. Thus, these items were suggested to have a special meaning for certain groups of students. Two gender-specific finding also emerged. For girls only, the MIs suggested that a substantial improvement in model fit would be gained by an additional specifying of an error covariance between successive Items 2 and 3. For boys only, the MIs suggested a correlated error between Items 2 and 3. These two item pairs may not be totally locally independent. The results from Model 2a also suggested that Items 10 and 16 have theoretically reasonable secondary loadings. Hayduk (1987, pp. 191-193; 1996, p. 31) has suggested that, when the errors are correlated and the correlations are substantially meaningful, it is doubtful that these are "errors." In such cases a better way to proceed is to replace the measurement errors with concepts and bring them into the model as model segments. Based on this logic, a new model was developed with the boys' data and then fitted to the girls' data. As shown in Table 2, the fit of the resulting 22-item model (Model 3) was acceptable for both gender groups. The final within-group model is presented in Figure 1.

Next, the invariance of the factor structures across gender was tested through a sequence of nested multigroup models. First, a multigroup baseline model was estimated. Because an acceptable reason for the misfit of the initial model had been found, Model 3 was used as a baseline model for both gender groups. Thus, a corresponding multigroup confirmatory factor analysis Model H_{form} was constructed

first. Because the chi-square is summative, the fit of this model was acceptable, S-Bχ^2(398) = 3215.62, CFI = 0.98, IFI = 0.98 and RMSEA=0.066. Having received support for the preliminary test of invariance (Model H$_{form}$), the testing of gender effects proceeded in a hierarchical fashion.

The invariance hypothesis, H$_\Lambda$, proposed that the two gender groups have equal factor loadings. All factor loadings were constrained to be equal across gender. This model was then compared to Model H$_{form}$, in which no equality constraints existed. The result of the $\Delta\chi^2$ test
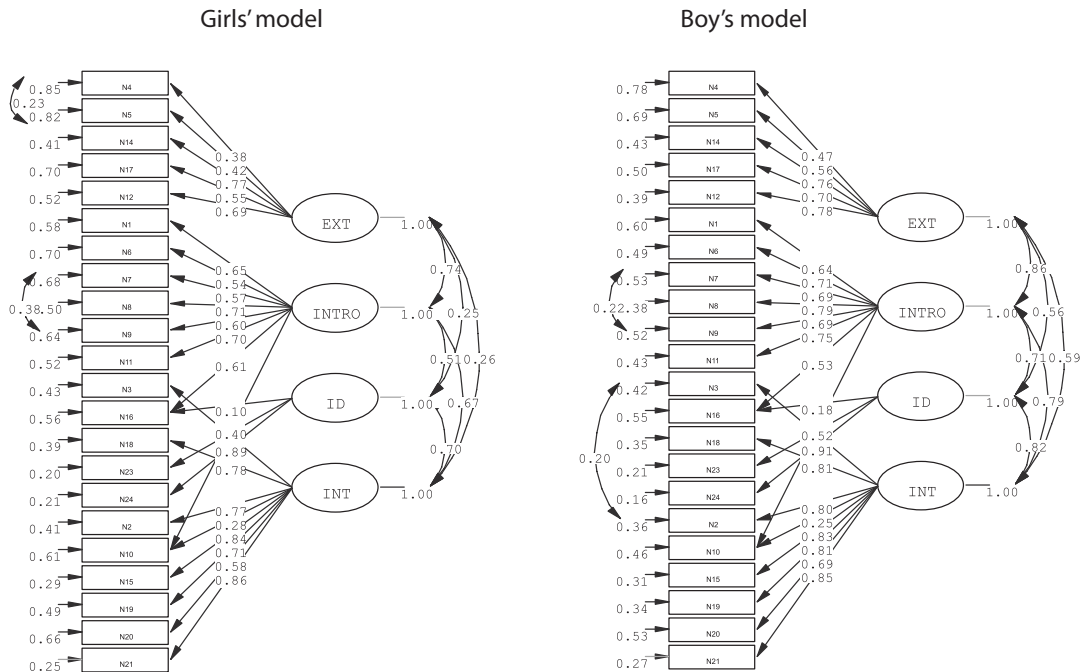

Figure 1:   The final student level models for girls and boys.

was statistically significant, thereby supporting the rejection of the hypothesis of invariant factor loadings (S-B$\Delta\chi^2$(24) = 433.41, p < 0.001). The examination of MIs suggested that the factor loadings of Items 6, 19 and 24 were not invariant across gender. The contents of these items describe behaviour that is not stereotypically considered to be feminine. Thus, relaxing these three factor loadings made theoretical sense. A new model was estimated were loadings of Items 6, 19 and 24 were estimated invariant across gender. Successively relaxing the constraints of Items 6, 19 and 24 yielded a substantial and statistically highly significant improvement in fit as compared to Model H$_\Lambda$, where all loadings were constrained as invariant (S-B$\Delta\chi^2$(3) = 181.63). On the other hand, when the final model was compared to the Model H$_{Form}$, the $\Delta\chi^2$-test still supported rejection of the model, thus indicating that the model still has some unjustifiable restrictions, S-B$\Delta\chi^2$(21)=251.78, p<0.001. However, because all additional respecifications suggested by MIs were theoretically questionable and in order to avoid capitalising on chance, no further respecifications were made. In addition, both the type-2 and type-3 fit indices of Model H$_{\Lambda*}$ were on an acceptable level, CFI = 0.98 and IFI = 0.98. Moreover, the RMSEA estimate was 0.067 and its 90 percent confidence interval from 0.065 to 0.069, thus supporting the conclusion that H$_{\Lambda*}$ was a good population model.

The next step was to test the invariance of the factor variances and covariances (H$_{\Lambda\phi}$). The result of the omnibus test (S-B$\Delta\chi^2$(6) = 35, p<0.001) supported the hypothesis of non-invariant factor variances and covariances. However, the goodness-of-fit measures remained quite high (e.g., CFI = 0.98 and IFI = 0.98). Moreover, the RMSEA estimates were the same as in model H$_{\Lambda*}$, thus supporting the conclusion that H$_{\Lambda\phi}$ was a good population model. Examination of MIs suggested that the factor variances were not invariant across gender. However, because of the relatively small MIs and to avoid capitalisation

on chance, the hypothesis of invariant factor covariances and variances was accepted with caution (cf. Steenkamp & Baumgartner, 1998).

Having obtained evidence for the partially invariant factor loadings and covariances, it made sense to compare the means of the four orientation factors (Model $H_{\Lambda vk}$). This was done using the method suggested by Byrne (1998). According to the fit indices, the model fitted the data quite well, S-B$\Delta\chi^2$(437) = 2873.78, $p < 0.001$, CFI = 0.98 and IFI = 0.98. In addition, the RMSEA estimate was 0.059 and had a 90 percent confidence interval from 0.057 to 0.061 which supported the partial scalar invariance. Thus, no further modifications were made to the model. A comparison of the factor means revealed that girls had a statistically higher mean score than did boys for all four factors, EXT (t=8.17), INTRO (t=11.58), ID ($t = 18.22$) and IM ($t = 16.17$).

The Between-Group Model

The next step was the specification of a school-level model for both gender groups. For this, the covariance matrices within and between schools were analysed using a multigroup procedure. As a first step towards the development of the school-level model, the four-factor student-level base model was expected to exist also on the school level. Then the full multilevel model was set up as a two-sample multiple-groups problem separately for girls and boys. However, the estimation procedure for this model did not converge. According to preliminary results from this model, the reason for this result seemed to be the high correlation among all four postulated factors. All correlations seemed to be near 1, and the factors collapsed into one new factor that can be interpreted as a General Motivational Orientation to study physics. That is, one general factor was enough to capture all between-class variation.Thus, a new model was constructed were only one general motivation factor was estimated at the school level. This multiple group model had a reasonable fit. The REMSA values were at an acceptable level, RMSEA$_{Girls}$=0.070 and RMSEA$_{Boys}$=0.076 (cf. Browne & Cudeck, 1993). Items 5 and 16 had the highest loadings on this General Motivational Orientation factor in girls' sample ($\lambda_{Item\,5}$=-0.47 and $\lambda_{Item\,16}$=0.23). In the boys' sample, Items 7 and 2 had the highest loading on this general factor ($\lambda_{Item\,5}$=-0.72 and $\lambda_{Item\,16}$=0.69).

Educational Correlates of the Four Motivation Factors

The boys and girls data were first analysed separately. However, the results of the boys' and girls' data were so similar that the data was decided to pool. As detailed in Table 3 (see Appendix B), teachers motivating and teaching style had expected connections to students' motivational orientations. Teacher's autonomy supportive teaching style correlated positively to all motivation factors whereas teacher's controlling teaching style had a weak negative or zero correlation to students' motivational orientations. Table 3 also shows that the more self-determined motivation the student has the better performance he or she has in physics learning. The connection was also almost linear between the motivational orientation and attitude to physics learning. That is, the more self-determined motivational orientation the student has the more positive attitude he or she has to physics learning.

Discussion

Self-determination theory (SDT) is one of the leading theories for understanding human motivation. SDT describes motivation as a continuum from amotivation to intrinsic motivation. Four extrinsic motivation categories lie between amotivation and intrinsic motivation. The main purpose of the present study was to test if the Physics Learning Orientation Scale (PLOS) measures four motivational orientations to study physics. According to the SDT, these four motivational orientations were intrinsic motivation (INT) and three kinds of extrinsic motivation, namely external regulation (EXT), introjected regulation (INTRO), and identified regulation (ID). The testing procedure was performed at two levels, at the student level and at the school level. A multilevel confirmatory factor analysis (MLCFA) was used to investigate the fit of the hypothesised four-factor model.

The results of the present study gave partial support to the hypothesised factor structure. However,

when the original set of items was used, the correlation between the factors Identified Regulation (ID) and Intrinsic Motivation (INT) was very high in both gender groups and the omnibus tests indicated that the correlation may even be 1 at the student level. This finding means that Identified Regulation and Intrinsic Motivation may be the same factors in the population. On the other hand, high or even perfect correlations between two dimensions do not necessarily mean that the concept behind the measurement is unidimensional rather than bidimensional. What this kind of finding means is that empirically the conceptually distinct concepts are almost perfectly correlated. According to Norwich (1999), it may also be possible that students cannot define intrinsic motivation without terms of identified regulation and intrinsic reasons for studying activities do not seem to be incompatible with extrinsic ones.

In the present study it was, however, possible to find item combinations where the correlation between Identified Regulation and Intrinsic Motivation factors was only high. This was done by using a post hoc CFA with both orthogonal and oblique factors and by eliminating two items from the scale. In general, the results of the revised PLOS revealed that in general boys seemed to have more difficulties making distinctions among the different motivational orientations than girls. For the boys' data, the factor correlations range from 0.56 to 0.86 with the mean correlation 0.72. For the girls' data, the factor correlations range from 0.25 to 0.74 with the mean correlation 0.52. Juuti, Lavonen, Uitto, Byman and Meisalo (2004) have found a similar tendency in gender differences in students' interest in physics in different contexts; girls were more sensitive than boys to changes in context. Physics as a discipline and school subject is claimed to be highly male-dominated. It may be that, girls are forced to conceptualise their relation to physics. Girls who are motivated and interested in physics are in the minority and have to rationalise their orientation. Meanwhile, boys follow the stereotype and are not subjected to thinking about their relationship to physics. At the school level, all factor correlations were one, and the a priori postulated four-factor model reverted to a general one-factor model. Thus, one general factor was sufficient to explain the covariances among motivation measures. This result means that the differences between schools are very small. This result is in line with the PISA results (see Lavonen & Laaksonen, 2009), which have shown that there are only minor differences between schools in different parts of Finland.

The possible variance components of instruments using written language are multiple. According to Johnson (1997), "pragmatic rules are implicit social conventions about meaning that can vary across subcultures who share the same language" (p. 81). Groves (1989, p. 450) differentiated three types of measurement errors associated with words. First, because different groups use different vocabularies, it is possible that the respondent can assign no meaning to used word. Second, a word can have different meanings to the same respondent. Third, a word can have different meanings for different respondents. In the present study, students interpreted criteria Items 3 and 18 differently than the way suggested by Ryan and Connell (1989). In the present study these two items measured INT instead of ID, or especially what Noels et al. (2003) called IM to know or IM knowledge. Because of this new specification and the elimination of two items, the ID factor was narrow, consisting only of three items. Two of these three items were new if compared to the items of the SRQ-A, and they measured how important students felt that physics was to their future plans.

In the present study, the invariance of the factor structures across gender was tested at the student level through a sequence of nested multigroup models. The results of this systematic testing procedure revealed that the factor loadings, factor variances and covariances were largely parallel for boys as well as for girls. Taken together, our Finnish data suggests that in terms of measure of motivational orientation to physics learning, boys and girls are not substantially different. However, after this systematic invariance testing, the comparison of the factor means revealed that girls had a statistically higher mean score than did boys for all four motivational orientation factors.

The second objective of the present study was to investigate different educational correlates of the four motivation factors. The resulted correlations of our study confirmed that identified regulation and intrinsic motivation correlates positively to performance in physics learning. These two motivational orientations had also a strong positive relationship with the attitude to physics learning. Relating to this topic, the results of our study gave further support to the results of Reeve and Jang (2006) according to which teacher's style of teaching and motivating students correlates with students' perceptions of autonomy.

Conclusions

According the results of the present study, the difference between the ID and INT dimensions of PLOS needs further clarification. Thus, more precise and more differentiated items are needed to measure the ID dimension. On the other hand, Hayduk (1996) has strongly emphasised that two or three items per factor are sufficient enough to measure a concept, otherwise confusion results instead of clarification.

The surprising result that girls had a statistically higher mean score than did boys for all four motivational orientation factors may reflect a difference in conscientiousness. That is, several studies (e.g., Colquitt & Simmering, 1998; Komarraju & Karau, 2005) have shown that girls are more conscientious than boys and that conscientiousness is positively related to the motivation to learn.

According to present study, both intrinsic motivation and also identified regulation of extrinsic motivation seem to be optimal motivational orientations to physics learning. Such instructional behaviours as for instance listening to students and joint-planning of lessons correlated positively with students' perceptions of autonomy and all four motivational orientation factors. Likewise, such instructional styles as monopolising the learning materials and directly telling the student a right answer instead of allowing the student time and opportunity to discover it correlated negatively with students' experience of autonomy. Thus, teacher's autonomy supportive teaching and motivating style produces academic and developmental benefits for their students also in physics learning (Reeve, 2002; see also Reeve, Jang, Carrell, Jeon & Barch, 2004).

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APPENDIX A

Physics Learning Orientation Scale (PLOS)

1. I try to do my best in physics learning because I will feel really bad about myself if I do not do well.
2. Learning physics is fun.
3. I learn physics because I want to learn new things.
4. I learn physics because that is what I am supposed to do.
5. I learn physics so that the teacher will not reproach me.
6. I try to answer difficult questions in class because I want the other students to think I am smart.
7. I learn physics because I want the teacher to think I am a good student.
8. I try to answer hard questions in class because I feel ashamed of myself when I do not try.
9. I try to succeed in physics learning because I want my teacher to think that I am a good student.
10. I try to answer difficult questions in class because it is fun to answer difficult questions.
11. I learn physics because I will be ashamed of myself if it did not get done.
12. I try to answer difficult questions in class because that's what I am supposed to do.
13. I try to answer difficult questions in class because I like to find out if I am right or wrong.
14. I try to do well in physics because that is what I am supposed to do.
15. I learn physics because it is fun.
16. I try to do well in physics and that is why I try to do my school work well.
17. I try to do well in physics because I will get in trouble if I do not do well.
18. I learn physics because I want to understand the subject.
19. I also think and read about things related to physics at home, because they interest me.
20. I learn physics because I can plan and decide myself about things which are related to school.
21. I learn physics because I am interested in it.
22. I do experiments related to physics at home and I discuss the experiments in school with other students.
23. I learn physics because I am going to study physics.
24. I learn physics because in the future I am going to choose an occupation where it is advantageous if I have studied physics.

APPENDIX B

Table 3. Educational Correlates of Motivational Orientations.

Educational correlates	External		Introjected		Identified		Intrinsic	
	Zero order r	Partial r	Zero order r	Partial r	Zero order r	Partial r	Zero order r	Partial r
Teaching style (autonomy supportive), Item 1	0.064**	0.015	0.116**	0.062**	0.140**	0.093**	0.193**	0.141**
Teaching style (autonomy supportive), Item 2	0.127**	0.106**	0.171**	0.131**	0.154**	0.101**	0.163**	0.086**
Teaching style (controlling), Item 1	-.0038*	-0.041*	-0.052**	-0.036*	-0.031	-0.025	-0.019	-0.040*
Teaching style (controlling), Item 2	0.006	0.014	-0.025	0.027	-0.007	0.023	0.030	0.006
Performance	0.068**	-	0.214**	-	0.295**	-	0.310**	-
Importance	0.014	-0.007	0.142**	0.039*	0.319**	0.187**	0.296**	0.120**
Physics is unnecessary-important	0.072**	0.050**	0.271**	0.052**	0.432**	0.105**	0.524**	0.111**
Physics is unpleasant-pleasing	0.053**	0.002	0.326**	0.190**	0.499**	0.278**	0.640**	0.430**

*$p<0.05$, two-tailed. **$p<0.01$, two-tailed.

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