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The effects of autonomy-supportive and controlling teaching behaviour in biology lessons with primary and secondary experiences on students' intrinsic motivation and flow-experience

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ABSTRACT

Self-Determination Theory and Flow Theory propose that perceived autonomy fosters the positive qualities of motivation and flow-experience. Autonomy-support can help to maintain students' motivation in very interesting learning activities and may lead to an increase in the positive qualities of motivation in less interesting learning activities. This paper investigates whether autonomy-supportive or controlling teaching behaviour influence students' motivation and flow-experience in biology class. In study 1, 158 students of grade six worked on the adaptations of Harvest Mice (*Micromys minutus*) with living animals. The 153 sixth graders of study 2 dealt with the same content but instead worked with short films on laptops. Previous studies have shown that students perceive film sequences as less interesting than working with living animals. Students' intrinsic motivation and flow-experience were measured at the end of the first and the third lesson. In study 1, autonomy-supportive teaching behaviour led to significant differences in students' intrinsic motivation and flow-experience when compared to controlling teaching behaviour. In study 2, motivation and flow-experience were not always in line with theory. The positive effects of autonomy-supportive and the non-beneficial effects of the controlling teaching behaviour seem to be dependent on the interestingness of the teaching material.

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Motivation; teaching methods; autonomy; affective domain; biology education; teacher actions

1. Introduction

One key characteristic of successful learning is students' motivation (Deci, Schwartz, Sheinman, & Ryan, 1981). Motivation facilitates learning and is essential to the entire learning process (Klauer & Leutner, 2007). Commitment (Flink, Boggiano, Main, Barrett, & Katz, 1992), learning success (Grolnick & Ryan, 1987) and skill acquisition (Weinert, 2002) all depend on students' motivation. Reeve (2009) argued that many teachers are unable to support or maintain students' motivation adequately. In fact, a decrease in students' motivation throughout their school careers, including in biology

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education, is reported (Eccles et al., 1993; Prokop, Tuncer, & Chudá, 2007). Ommundsen and Kvalø (2007) found that an important factor in supporting students' motivation was teaching behaviour. In particular, their work supported Deci and Ryan's (1985, 2000) claim that autonomy-supportive teaching behaviour fosters a positive motivational state while controlling behaviour can undermine it. Evidence in support of their ideas has also come from work contrasting interesting vs. uninteresting activities (Joussemet, Koestner, Lekes, & Houltfort, 2004) such as solving interesting puzzles (Boggiano, Flink, Shields, Seelbach, & Barrett, 1993; Grolnick & Ryan, 1987; Mouratidis, Lens, & Vansteenkiste, 2010; Ryan, Koestner, & Deci, 1991) and computerised vigilance tasks (Joussemet et al., 2004).

The aim of our studies was to investigate whether the results from previous laboratory studies could be supported in a real-life classroom environment, and specifically in the context of biology lessons. We conducted two studies that examined the effects of autonomy-supportive or controlling teaching behaviour using different media. Following a previous study by Wilde, Hussmann, Lorenzen, Meyer, and Randler (2012), study 1 involved the use of living animals that are perceived as very interesting. Study 2 instead used short films of the same living animals displayed on laptops that are perceived as less interesting.

2. Theoretical framework

2.1. Intrinsic motivation and flow-experience

In their Self-Determination Theory, Deci and Ryan (1985, 2000) propose that there are three basic psychological needs, that is, relatedness, competence and autonomy, that are innate to human beings. The need for relatedness manifests as the drive to integrate into a social environment or to interact with important others (Deci & Ryan, 2000). Competence refers to the ability to act and master challenges (Deci & Ryan, 1985; White, 1959). If the requirements meet the individuals' skills, the need for competence may be satisfied (Deci & Ryan, 2000). The need for competence is related to the need for autonomy. These needs are mutually dependent (Deci & Ryan, 1985; Krapp & Ryan, 2002). The need for autonomy comprises the perception of being the origin of one's own behaviour (Reeve, 2002). Reeve, Nix, and Hamm (2003) argue that three qualities are essential to satisfying this need: volition, locus of causality and choice. Volition constitutes the ambition to act by one's own choice and without external influences. Actions should be carried out only if there is interest in doing so. This does not mean that a person seeks to be completely unaffected by their environment and that intrinsic motivation can only be experienced without external influences. Instead, tasks should correspond to what the person would like to do at the moment and should have personal relevance (Krapp & Ryan, 2002). Locus of causality describes the individual's belief about the origin of the behaviour. There is a distinction between an internal and an external locus of causality. The locus of causality is exterior to the acting persons when there is a feeling of external control (Reeve et al., 2003) and the persons experience themselves as pawns (deCharms, 1968). The locus of causality is interior and the individuals experience themselves as origin of their own behaviour (deCharms, 1968) when they feel strongly self-regulated. Choice includes presenting options. As such, the acting person should feel a real choice about whether to act or not (deCharms, 1977). Meaningful and real choice can foster the perception of the two other autonomy-supportive components, volition and locus of causality (Reeve et al., 2003).

The fulfilment of the psychological needs determines the quality of motivated behaviour. In their Self-Determination Theory, Deci and Ryan (1985, 2000) describe extrinsic and intrinsic motivation. Activities are considered to be extrinsically motivated when they are carried out for instrumental reasons. Extrinsically motivated activities can have different motivational qualities (Deci & Ryan, 1985, 2000). Deci and Ryan (1985, 2000) differentiate four types of extrinsically motivated behaviour that exist on a continuum ranging from heteronomous to autonomous, and range from externally motivated regulation to integrated regulation. An activity is intrinsically motivated when the reward is its performance in and of itself. Intrinsically motivated activities comprise spontaneity, curiosity and interest (Ryan & Deci, 2000). It correlates positively with the experience of flow (Taylor, Schepers, & Crous, 2006), as well as being its antecedent (Kowal & Fortier, 1999).

Csikszentmihalyi's (1975) Flow Theory describes a perspective complementary to motivation. He focuses on a certain intrinsic quality of motivation experienced while acting, the flow-experience (Krombass & Harms, 2006). Csikszentmihalyi (1977, p. 36) defines flow-experience as 'the holistic sensation that people feel when they act with total involvement'. Flow-experience can be characterised by the following components: (1) clear goals, (2) clear and immediate feedback, which the acting person can perceive permanently, (3) the merging of action and awareness, (4) high level of attention to a limited stimulus field, (5) a sense of control of action and environment, (6) loss of self-consciousness, (7) autotelic experience, meaning that the activity is its own reward, (8) altered time perception and (9) a feeling of control and competence (Csikszentmihalyi, 1977). The fulfilment of these components is dependent on an optimal matching between the perceived task difficulty and the individual's competences (Csikszentmihalyi, 1975, 2000). When the individual's skills and the challenge determined by the task are thought to be perceived as above-average, flow-experience can occur (Massimini & Carli, 1991). The need for competence can be satisfied simultaneously (Deci & Ryan, 2000; Krombass, Urhahne, & Harms, 2007). Csikszentmihalyi (1975, 2010) lists only process-related requirements for flow. Person-related factors that influence flow are not considered (Taylor et al., 2006). Taylor et al. (2006) suggest that the experience of autonomy can be added as a further requirement given that it can foster the merging of action and consciousness. Kowal and Fortier (1999) found a positive correlation between perceived autonomy and flow-experience, as well as between intrinsic motivation and flow-experience. Intrinsic motivation as described by Deci and Ryan (1985, 2000) and flow-experience as described by Csikszentmihalyi (1975) are both associated with a variety of positive effects on students' learning. Csikszentmihalyi (1992) found a positive correlation between students' flow-experience, their creativity and academic achievement, as well as an increase in self-esteem. Similar correlations are reported between students' intrinsic motivation and their learning success, perceived competence, performance and creativity (Reeve, Bolt, & Cai, 1999). Considering the benefits that arise from students' intrinsic motivation and flow-experience, the current study investigated whether autonomy-supportive teaching behaviour could foster these qualities of motivation in biology lessons.

2.2. Autonomy-supportive vs. controlling teaching behaviour and its effects on motivation in biology education

Students' motivation, as well as their attitude towards biology depends, at least in part on their teachers' behaviour (Ommundsen & Kvalø, 2007; Prokop et al., 2007; Reeve, 2002). Teachers usually tend to exhibit either autonomy-supportive or controlling teaching behaviours (Reeve, 2009). Controlling teachers put their students under time pressure, threat of punishment for non-execution, use external stimuli to motivate their students (Deci, 1971; Reeve, 2002; Reeve et al., 1999) and provide controlling feedback (Ryan, 1982). Controlling teaching behaviour may in fact foster extrinsic types of motivation and undermine intrinsic motivation. This undermining effect conveys an instrumental character by offering external stimuli (Deci & Ryan, 2000). Extrinsically motivated activities divest the acting person of control over his or her own actions, and can lead to a diminished flow-experience (Bakker, Oerlemans, Demerouti, Bruins Slot, & Karamat Ali, 2011). In contrast, autonomy-supportive teaching behaviour comprises the expression of appreciative feelings (Reeve et al., 1999), informative feedback (Ryan, 1982), an increased students' speech ratio, as well as possibilities for choice (Reeve, 2002). Student participation in biology education has been found to affect students' intrinsic motivation positively (Meyer-Ahrens, Moshage, Schäffer, & Wilde, 2010; see also Meyer-Ahrens & Wilde, 2013).

In addition, extrinsically motivated activities in learning environments with less interesting types of presentation can gain importance for the acting person due to autonomy-support (Ryan & Deci, 2000). Self-regulated forms of motivation may be fostered due to internalisation (Ryan & Deci, 2000). Autonomy-support and control operate differently when varying interesting types of presentation. Autonomy-support can maintain intrinsic motivation, whereas control can convey an instrumental character. Autonomy-support can thwart the instrumental character of uninteresting and extrinsically motivated activities in learning environments with less interesting types of presentation. In contrast, controlling teaching behaviour can maintain the instrumental character of the activity in the same learning environment.

The use of living animals is a common feature of biology education, and seem to be an appealing type of presentation, especially for younger students (Dohn, Madsen, & Malte, 2009; Sammet, Kutta, & Dreesmann, 2015). Hummel (2011) reports that living mice in biology lessons lead to distinctly higher interest and enjoyment in comparison to other frequently used animals. In contrast, students perceive video sequences of mice as less interesting and less motivating (Hummel, 2011; Wilde et al., , 2012). In this context, a teaching unit about harvest mice seemed to be appropriate for examining the motivational effects of autonomy-supportive vs. controlling teaching behaviour in learning environments with very interesting (study 1) and less interesting (study 2) types of presentation (Table 1).

3. Hypotheses

Taking into account students' decreasing motivation in biology education in high school, biology teachers are increasingly confronted with the problem of supporting students' motivation (Eccles et al., 1993; Prokop et al., 2007). Hummel and Randler (2012) proposed

Table 1. 2*2 design of both studies. Two factors were varied, namely the teaching behaviour (autonomy-supportive vs. controlling) and the type of presentation (living animals vs. video sequences).

	Study 1 (living animals) *V*ery *I*nteresting type of presentation (VI)	Study 2 (video sequences) *L*ess *I*nteresting type of presentation (LI)
*A*utonomy-supportive teaching behaviour (A)	*VI/A*	*LI/A*
*C*ontrolling teaching behaviour (C)	*VI/C*	*LI/C*

the use of living animals in biology classes to support motivation. Living animals provide an authentic connection to learning content. They enable primary experiences and are associated with intrinsic motivation (Wilde et al., 2012) and high interest (Hummel & Randler, 2012). Laboratory studies (Boggiano et al., 1993; Grolnick & Ryan, 1987; Mouratidis et al., 2010; Ryan et al., 1991) revealed that the presentation of interesting learning content alone is insufficient to maintaining students' motivation. These studies emphasised the significance of teaching behaviour in students' motivation. Autonomy-support, in contrast to controlling teaching behaviour, fostered positive qualities of motivation in out-of-school-learning environments (Basten, Meyer-Ahrens, Fries, & Wilde, 2014). As such, the experience of autonomy is crucial to intrinsically motivated activities (Tessier, Sarrazin, & Ntoumanis, 2010).

The aim of study 1 was to examine the effects of autonomy-supportive and controlling teaching behaviour, in learning environments with very interesting teaching material in biology lessons, on students' intrinsic motivation and flow-experience. For this purpose, a teaching unit of three lessons was designed in which the students investigated the habitual adaptations and climbing abilities of harvest mice. This topic was selected given evidence that mice are perceived as particularly interesting to fifth and sixth graders (Hummel & Randler, 2012). At the same time, mice are associated with a distinctly higher perception of choice, in comparison to frequently used animals such as isopods or snails (Hummel, 2011). It is thought that autonomy-supportive teaching behaviour can support the sense of choice facilitated by the living animals whereas controlling teaching behaviour can undermine it.

On the other hand, not every lesson can contain authentic encounters and primary experiences. Not all schools keep animals and not all teachers can organise zoo visits for every biology lesson. In fact, most lessons will only be sparsely interesting, and teachers will not always be able to take students' interests into account (Ryan, Connell, & Deci, 1985). As such, study 2 was designed to examine whether intrinsic motivation and flow-experience could be fostered by autonomy-support in biology lessons with less interesting media. A thematically identical teaching unit was conducted that contained video sequences of the mice instead of living animals. The films were shown without sound, and the length of each sequence was kept short to reduce students' cognitive load (Sammet et al., 2015). The video sequences were intended to provide only secondary experiences (Wilde et al., 2012), that would be perceived as distinctly less interesting (Hummel, 2011) and less motivating (Wilde et al., 2012). Autonomy-supportive teaching behaviour is thought to support and maintain positive motivational qualities in learning environments with very interesting types of presentation. In learning environments with less interesting types of presentation, autonomy-support is thought to foster self-regulated motivational states.

The hypotheses for both studies were:

H1. Autonomy-supportive teaching behaviour leads to more intrinsic motivation than controlling teaching behaviour

(1) in very interesting biology lessons (study 1).

(2) in less interesting biology lessons (study 2).

The experience of autonomy can foster the merging of activity and consciousness, as well as the sense of being the origin of one's own actions (Bakker et al., 2011), and is one of the requirements of flow-experience (Taylor et al., 2006). Bakker et al. (2011) assume that autonomy-supportive styles of communication and the associated performance feedback affect flow-experience positively. Kowal and Fortier (1999) found a positive correlation between perceived autonomy and flow-experience. Even so, students' flow-experience seems to be dependent on the type of presentation. Meyer, Klingenberg, and Wilde (2015), claimed that learning environments that offer primary experiences, such as working with living animals, could lead to a greater experience of flow than secondary experiences such as working with short films on laptops.

This lead to the following hypotheses:

H2. Autonomy-supportive teaching behaviour leads to more flow-experience than controlling teaching behaviour

(1) in very interesting biology lessons (study 1).

(2) in less interesting biology lessons (study 2).

4. General methods

Two quasi-experimental studies were conducted in sixth grade classrooms at German schools. There were no differences in content or method between studies 1 and 2. Only the type of presentation differed: living animals (study 1) and video sequences of harvest mice (study 2). The teaching behaviour (autonomy-supportive vs. controlling) was the only factor varied within the studies.

4.1. Sample

The sample for study 1 was composed of six high school classes ($N = 158$). The sample consisted of 86 girls and 72 boys. The students' age ranged between 11 and 13 years. The average student was 11.98 years old (SD = 0.36 years). Three of the classes were taught in an autonomy-supportive manner (A-treatment; $n = 80$) and three using a controlling manner (C-treatment; $n = 78$).

The sample for study 2 was also composed of six high school classes ($N = 153$). The sample consisted of 83 girls and 70 boys. The average student was 11.95 years old (SD = 0.91 years). As in study 1, three of the classes were taught in an autonomy-supportive manner (A-treatment; $n = 83$) and three using a controlling manner (C-treatment; $n = 70$).

4.2. Test instruments

Identical test instruments were used in both studies (study 1 and study 2). All applied testing instruments were evaluated in external studies (McAuley, Duncan, & Tammen, 1989; Wilde & Bätz, 2009) and fulfilled the quality criteria. The test instruments are described in the following paragraphs.

4.2.1. Self-Regulation Questionnaire

An adapted version of the Self-Regulation Questionnaire (SRQ) by Ryan and Connell (1989) was used to ensure that students in the A- and C-treatments had the same motivational preconditions at the beginning of the teaching unit (Müller, Hanfstingl, & Andreitz, 2007). The students rated their long lasting motivation on a five-point rating scale, ranging from ‘strongly disagree’ (0) to ‘strongly agree’ (4). Data gathered with the adapted SRQ was used to calculate the Relative Autonomy Index (RAI). The subscales can be plugged into the following formula: 2*intrinsic + integrated – (introjected + 2*external). RAI can attain values ranging from −12 to +12. The closer the value of the RAI is to −12, the more the students can be described as feeling heteronomous, whereas a value closer to +12 indicates feelings of self-determination (Ryan & Connell, 1989).

4.2.2. Perceived Self-Determination

A modified version of the Perceived Self-Determination questionnaire (PSD) was administered at the end of the first and third lessons (Reeve, 2002; Reeve et al., 2003). This questionnaire captures the students’ autonomy-experience and can be used to examine whether the operationalised controlling or autonomy-supportive teaching behaviour in the C- or A-treatment succeeded equally. The PSD captures the three autonomy-supportive components, namely volition, locus of causality and choice, with 10 items (Table 2). The items are scored using a five-point rating scale (0 = strongly disagree to 4 = strongly agree).

4.2.3. Intrinsic Motivation Inventory

Students’ current motivation was evaluated using the adapted Intrinsic Motivation Inventory (A-IMI) at the end of the first and third lessons. The A-IMI is a shortened version of

Table 2. Cronbach’s alpha-values (α), example items as well as number of items of the subscales for study 1 ($\alpha 1$) and study 2 ($\alpha 2$) at both measuring times.

Test instruments	Example item	$\alpha 1$	$\alpha 2$
SRQ	I study my biology lessons, …		
External	… because I will get a bad grade if I don’t (4)	.550	.706
Introjected	… because I will feel bad about myself if I don’t do it (3)	.601	.609
Integrated	… because it fits the way I see myself (6)	.858	.741
identified	… because the knowledge in biology will help me to get a good job (4)	.873	.818
Intrinsic	… because it’s fun (5)	.877	.816
PSD	In this lesson I was pursuing my own goals, goals that were important to me (10)	.750/.815	.732/.831
FSS	I feel that I have everything under control (10)	.796/.850	.799/.797
IMI			
Interest/enjoyment	This activity was fun to do (3)	.720/.855	.765/.787
Perceived choice	I could control the activity by myself (3)	.775/.752	.745/.804
Perceived competence	I worked skillfully at this activity (3)	.856/.845	.757/.806
Pressure/tension	During acting in this lesson I felt stressed (3)	.775/.752	.620/.622

Ryan's (1982) and Ryan, Connell, and Plant's (1990) IMI (Wilde, Bätz, Kovaleva, & Urhahne, 2009). It captures twelve items and is comprised of the positive predictors of intrinsic motivation containing *interest/enjoyment*, *perceived choice* as well as *perceived competence* and the negative predictor of intrinsic motivation *pressure/tension* (Table 2). The items were scored using a five-point rating scale (0 = strongly disagree to 4 = strongly agree).

4.2.4. Flow Short Scale

The Flow Short Scale (FSS) with a five-point rating scale was used to capture the state of flow (Rheinberg, Vollmeyer, & Engeser, 2003). This scale comprises the components 'fluency of performance' with six items, and 'absorption by activity' with four items (Rheinberg et al., 2003; Table 2). In addition, the brevity of the questionnaire allows for the activity being assessed to be interrupted only briefly (Rheinberg et al., 2003).

4.3. Test design and teaching process

The designs for study1 and for study 2 were identical (Figure 1). The questionnaires measured students' autonomy-experience as well as their quality of motivation before and during the study.

One week before the beginning of the study, the SRQ was administered to ascertain the students' long-term motivation for biology lessons which could be influenced by the teacher's invariant behaviour throughout several lesson units. By capturing students' long-term motivational state, it is possible to compare motivational preconditions between the groups and consider them in the analysis of students' current motivation. Students' motivation can also be affected by the use of appealing subject matter as well as by the media chosen (Hidi, 2000; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). The topics in the curriculum correspond with students' interests differently (Meyer-Ahrens, Meyer, Witt, & Wilde, 2014). The classes that participated in the study usually have dealt with different issues before the beginning of the study. We ensured that none of the classes had prior experience with animals as presented in the studies. Data from the PSD, the FSS and the A-IMI were administered to the students at the end of the first and third lessons. The students' current motivation was evaluated using the IMI that according to Engeser, Rheinberg, Vollmeyer, and Bischoff (2005), can influence the students' flow-experience.

In the first two lessons, the students created a profile of the Eurasian Harvest mouse and formed small groups to examine its climbing ability as a means to understanding its adaptations to its habitat. The lesson unit was adapted from that designed by Wilde, Meyer, and Klingenberg (2010) for the first progression stage per the requirements for a biology curriculum, in which animals in special environments are a required component. Results of the first two lessons were presented in the third lesson in plenum. The teaching behaviour (autonomy-supportive vs. controlling) was the only factor varied within the studies. The characteristics described by Reeve and Jang (2006) and Reeve (2002) were assigned to the three autonomy-supportive components, namely volition, locus of causality and choice to standardise autonomy-supportive and controlling teaching behaviour, respectively (Table 3). The study was conducted by three teacher trainees who were close to completing their degrees. The participating classes were randomly assigned to the teacher trainees. To

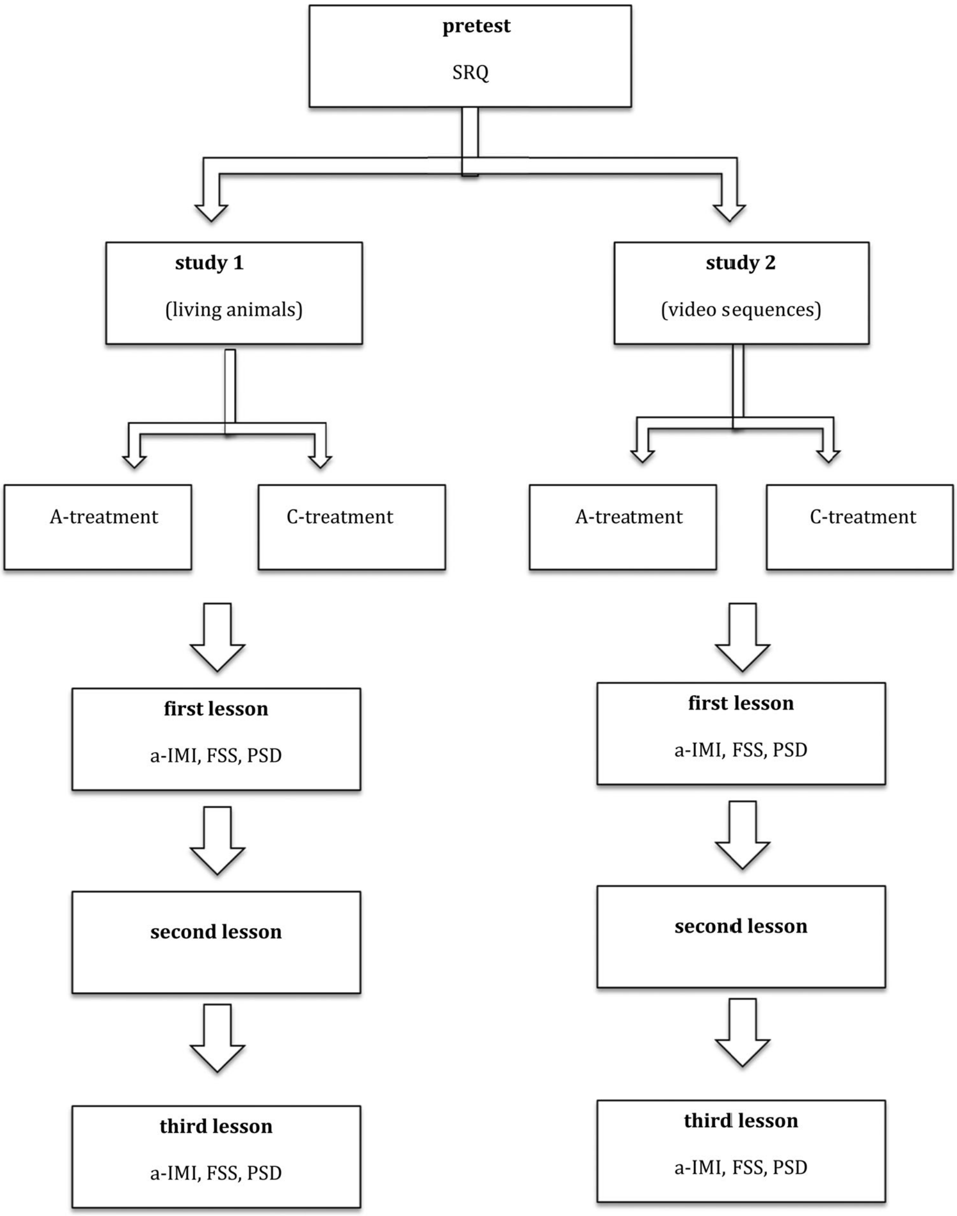

Figure 1. Design of the study. The intervention consisted of three lessons. The SRQ was administered before the beginning of the study. Students' intrinsic motivation (A-IMI), flow-experience (FSS), and autonomy-experience (PSD) were measured at the end of the first and the third lesson.

ensure that the specific behaviour (autonomy-supportive and controlling teaching behaviour) or rather the instruction were clearly understood and could therefore be implemented, the teachers attended several meetings to learn the target autonomy-supportive and controlling behaviours. All teacher trainees performed each treatment equally often. They showed controlling behaviour in the C-treatment, and autonomy-supportive behaviour in the A-treatment. Since it is possible that any possible effects might be

Table 3. Operationalisation of the autonomy-supportive (A-treatment) and the controlling (C-treatment) teaching behaviour.

	A-treatment	C-treatment
Locus of causality	Informative feedback e.g. 'You worked properly' Teaching unit was not graded	Controlling feedback e.g. 'You took the mice out of the cage like I told you' Teaching unit was graded
Volition	No pressure e.g. 'You might … ', 'If you like to … '	Pressure e.g. 'You are supposed to … ', 'You have to … '
Choice	Choices e.g. Students were allowed to choose the succession of tasks	No choices e.g. Succession of tasks was determined by the teacher

attributable to teacher personality (Reeve, 1998, 2002), the teachers were treated as covariates in all tests.

5. Results of study 1 (living animals)

As a preliminary result, lessons with living animals were regarded as especially interesting and engaging. Autonomy-supportive and controlling teaching behaviour, respectively, might influence the students' motivation particularly in these lessons. The RAI was reported to ensure equal levels of pupils' perceived self-regulation in regular biology lessons. ANOVAs revealed no significant differences between students of A- and C-treatment (Table 4). RAI-values were slightly positive. This indicates that students of both treatments felt sparsely self-regulated in normal biology education (Table 4). Possible differences between the classes were considered as covariates in an analysis of covariance (ANCOVA) and revealed no significant differences (Table 4). Before our treatments all classes felt equally self-regulated.

The average of the PSD in terms of ANOVA was compared at both measuring times to make sure that the implementation of the autonomy-supportive and controlling teaching behaviour was successful and that these behaviours were perceived as such by the students. ANOVAs revealed significant differences between students of A- and C-treatment (Table 4). Students of the autonomy-supportive treatment experienced themselves as more autonomous than students who were treated in a controlling manner. Effects attributable to the teacher were also treated as covariates. Teachers differed non-significantly at both measuring times. This suggests that the implementation of autonomy-supportive and controlling teaching behaviour succeeded equally well with all teachers.

Regarding the first hypothesis, the results of the A-IMI were reported to investigate whether students in both treatments differed in their motivational state. Subscales of the A-IMI were compared between both treatments with a multivariate analysis of variance (MANOVA) to evaluate the findings involving intrinsic motivation. MANOVA revealed significant differences between students of A- and C-treatment in the subscales *perceived choice*, *perceived competence* as well as *pressure/tension* in favour of autonomy-support for both times (Table 4). In the subscale *interest/enjoyment* we found no significant differences between students of both treatments at any measuring time (Table 4). In the A-IMI, the teacher was also considered as a covariate and revealed no significant effects in the subscales of the A-IMI at any measuring time (Table 4).

Table 4. Effect sizes, *F*-values, means (*M*) and standard deviation (SD) of the autonomy-supportive (A-treatment) and the controlling (C-treatment) in the (sub)scales of the SRQ, the PSD, the A-IMI as well as the FSS at the first and second measuring time (study 1) including possible teacher-related effects (covariate).

		A-treatment *M* (SD)	C-treatment *M* (SD)	*F*-values (*p*-values)	η^2
SRQ	RAI	2.20 (3.67)	2.93 (3.22)	F(1;145) = 1.74 (ns)	0.01
	Teacher			*F(1;145) = 0.58 (ns)*	*0.00*
PSD	First	2.82 (0.74)	2.34 (0.61)	F(1;145) = 19.55 (***)	0.11
	Teacher			*F(1;145) = 3.21 (ns)*	*0.02*
	Second	1.65 (0.76)	2.30 (0.64)	F(1;142) = 9.51 (**)	0.06
	Teacher			*F(1;142) = 0.52 (ns)*	*0.00*
IMI first	Interest/enjoyment	3.43 (0.76)	3.36 (0.79)	F(1;145) = 0.52 (ns)	0.00
	Teacher			*F(1;145) = 2.23 (ns)*	*0.02*
	Perceived choice	2.57 (0.94)	1.87 (0.93)	F(1;145) = 19.88 (***)	0.13
	Teacher			*F(1;145) = 0.72 (ns)*	*0.01*
	Perceived competence	3.06 (0.83)	2.63 (0.89)	F(1;145) = 7.76 (**)	0.05
	Teacher			*F(1;145) = 1.15 (ns)*	*0.01*
	Pressure/tension	1.09 (1.10)	1.44 (1.00)	F(1;145) = 4.87 (*)	0.04
	Teacher			*F(1;145) = 3.35 (ns)*	*0.02*
IMI second	Interest/enjoyment	3.06 (0.97)	3.25 (0.89)	F(1;142) = 1.50 (ns)	0.01
	Teacher			*F(1;142) = 0.35 (ns)*	*0.00*
	Perceived choice	2.48 (1.03)	1.95 (0.93)	F(1;142) = 10.47 (**)	0.07
	Teacher			*F(1;142) = 0.43 (ns)*	*0.00*
	Perceived competence	3.05 (0.88)	2.54 (0.91)	F(1;142) = 11.70 (**)	0.08
	Teacher			*F(1;142) = 0.34 (ns)*	*0.00*
	Pressure/tension	1.16 (0.99)	1.48 (0.89)	F(1;142) = 4.16 (*)	0.03
	Teacher			*F(1;142) = 0.82 (ns)*	*0.00*
FSS	First	2.80 (0.59)	2.52 (0.54)	F(1;145) = 10.27 (**)	0.07
	Teacher			*F(1;145) = 5.03 (*)*	*0.03*
	Second	2.81 (0.66)	2.48 (0.59)	F(1;142) = 10.23 (**)	0.07
	Teacher			*F(1;142) = 1.76 (ns)*	*0.01*

* $p \leq .05$.
**$p \leq .01$.
***$p < .001$.

Regarding the second hypothesis, the results of the FSS were reported to examine differences in students' flow-experience for both treatments. Values of the FSS were compared using ANOVA to examine the effects of the respective treatment on the immediate quality of experience. The FSS revealed significant differences between students of the A- and the C-treatment at both measuring times. The autonomy-supported students experienced distinctly higher flow on average compared to the students of the C-treatment at both measuring times (Table 4). Effects of the teacher on the FSS were considered as a covariate at both measuring times, and revealed a significant effect at the first measuring time (Table 4).

6. Results of study 2 (video sequences)

In study 2, the preliminary results for the RAI-values using ANOVA revealed no significant differences between the students of both treatments (Table 5). Possible motivational teacher effects were considered with ANCOVA and revealed no significant differences either (Table 5).

The second preliminary results examined whether the operationalised autonomy-supportive and controlling teaching behaviours were perceived as such by the students. The means of the PSD of both treatments were compared using ANOVA. Students who were exposed to autonomy-support experienced themselves as distinctly more self-regulated at both measuring times as the students in the controlling scenario (Table 5). Here, the ANCOVA revealed significant differences between the teachers at the first measuring time (Table 5). Operationalisation of autonomy-support and control did not seem to have succeeded equally.

Analogous to study 1, the results of the A-IMI were reported to investigate whether students of both treatments differed in their motivational state. A MANOVA was applied to calculate differences in students' intrinsic motivation in the respective treatments, and revealed a significant difference in the subscales *perceived competence* as well as *pressure/tension* in favour of the autonomy-supportive treatment at the first measuring time (Table 5). The subscales *perceived choice* as well as *interest/enjoyment* showed higher values in the autonomy-supportive treatment, but the difference was not significant (Table 5). Analysis of covariance revealed significant teacher-dependent effects in the subscales *perceived choice* and *pressure/tension* (Table 5).

Students of both treatments differed in the subscales *perceived choice*, *perceived competence* as well as perceived *pressure/tension* at the second measuring time (Table 5). Students of A-treatment reported having more choices and feeling more competent than the students of C-treatment. Students of C-treatment, in turn, felt more *pressure/tension*. No significant difference in the subscales *interest/enjoyment* at the second

Table 5. Effect sizes, *F*-values, means (*M*) and standard deviation (SD) of the autonomy-supportive (A-treatment) and the controlling (C-treatment) in the (sub)scales of the SRQ, the PSD, the A-IMI as well as the FSS at the first and second measuring time (study 2) including possible teacher-related effects (covariate).

		A-treatment *M* (SD)	C-treatment *M* (SD)	*F*-values (*p*-values)	η^2
SRQ	RAI	3.35 (3.33)	3.04 (3.05)	$F(1;151) = 0.38$ (ns)	0.00
	Teacher			*$F(1;151) = 0.49$ (ns)*	*0.00*
PSD	First	2.51 (0.54)	2.14 (0.71)	$F(1;146) = 13.06$ (**)	0.08
	Teacher			*$F(1;146) = 4.77$ (*)*	*0.03*
	Second	2.53 (0.67)	2.07 (0.72)	$F(1;137) = 15.54$ (***)	0.10
	Teacher			*$F(1;137) = 0.15$ (ns)*	*0.00*
IMI first	Interest/enjoyment	3.03 (0.67)	2.78 (0.84)	$F(1;146) = 3.83$ (ns)	0.03
	Teacher			*$F(1;146) = 1.60$ (ns)*	*0.01*
	Perceived choice	2.32 (0.92)	2.15 (0.92)	$F(1;146) = 1.34$ (ns)	0.01
	Teacher			*$F(1;146) = 7.59$ (**)*	*0.05*
	Perceived competence	2.65 (0.69)	2.27 (0.87)	$F(1;146) = 8.48$ (**)	0.06
	Teacher			*$F(1;146) = 0.01$ (ns)*	*0.00*
	Pressure/tension	1.22 (0.81)	1.55 (0.89)	$F(1;146) = 5.80$ (*)	0.04
	Teacher			*$F(1;146) = 4.05$ (*)*	*0.03*
IMI second	Interest/enjoyment	2.81 (0.98)	2.59 (0.89)	$F(1;137) = 1.87$ (ns)	0.01
	Teacher			*$F(1;137) = 0.00$ (ns)*	*0.00*
	Perceived choice	2.30 (0.89)	1.70 (1.02)	$F(1;137) = 13.06$ (***)	0.09
	Teacher			*$F(1;137) = 0.12$ (ns)*	*0.00*
	Perceived competence	2.71 (0.79)	2.37 (0.82)	$F(1;137) = 5.85$ (*)	0.04
	Teacher			*$F(1;137) = 0.38$ (ns)*	*0.00*
	Pressure/tension	1.17 (0.80)	1.46 (0.86)	$F(1;137) = 4.40$ (*)	0.03
	Teacher			*$F(1;137) = 5.78$ (*)*	*0.04*
FSS	First	2.61 (0.46)	2.41 (0.56)	$F(1;146) = 5.94$ (*)	0.04
	Teacher			*$F(1;146) = 4.97$ (*)*	*0.03*
	Second	2.62 (0.55)	2.45 (0.57)	$F(1;137) = 2.93$ (ns)	0.02
	Teacher			*$F(1;137) = 0.51$ (ns)*	*0.00*

*$p \leq .05$.
**$p \leq .01$.
***$p < .001$.

measuring time could be discovered (Table 5). Effects of the teacher were considered as covariate and no significant impact was revealed in any subscale of the A-IMI (Table 5).

Regarding the second hypothesis, the results of the FSS are reported to examine differences in the students' flow-experience of both treatments. Items of the FSS were compared by use of ANOVA to gather the effects of teaching behaviour on the immediate qualities of experience. The FSS revealed a significant difference between the students of both treatments at the first measuring time. Autonomy-supported students experienced a higher flow on average than students who were treated in a controlling manner (Table 5). Students of both treatments did not differ in their flow-experience at the second measuring time any more (Table 5). ANCOVA revealed a significant teacher-dependent effect only at the first measuring time.

7. Discussion

The aim of both studies was to examine the effects of autonomy-supportive and controlling teaching behaviour on students' intrinsic motivation and flow-experience. In study 1, we designed biology lessons with living animals intended to be very interesting to students. For study 2, we designed biology lessons with video sequences with the same content intended to be less interesting. We used short films on laptops instead of living animals. The findings for study 1(living animals) were consistent with the theory. The only exception here was found in the subscale *interest/enjoyment*. In addition, data from study 2 (video sequences) were not always consistent with the theory.

Living animals were used in study 1 as an especially interesting type of presentation. Although the study was conducted by three female teachers, and possible effects for every compiled construct were considered, no teacher-dependent effect was revealed in any of the constructs with the exception of flow-experience in the first measuring time. This teacher-dependent effect was moderate. Differences in perceived autonomy gathered by the PSD questionnaire indicate that the operationalisation and implementation of the autonomy-supportive and controlling teaching behaviour were successful.

In the subscale *perceived choice* of the A-IMI, autonomy-supported students also stated that they had experienced a distinctly broader range of choice than students in the controlling treatment. Ryan and Deci (2002) propose that competence- and autonomy-experience are mutually dependent. Koestner, Zuckerman, and Koestner (1987) found that autonomy-support could be associated with competence-support. These findings are in line with the results of the current study. Autonomy-supported students experienced themselves as more competent than the students of the controlling treatment at both measuring times. The students differed significantly across treatments in all subscales with the exception of the subscale *interest/enjoyment*. The means for both treatments in the subscale *interest/enjoyment* may indicate a ceiling effect. Wilde et al. (2012) revealed similar findings. Living animals are associated with very high interest and high motivation (Hummel & Randler, 2012; Wilde et al., 2012). The controlling teaching behaviour did not decrease the students' *interest/enjoyment*. The controlling teaching behaviour that students typically experience in regular education (Martinek, 2010) may explain the small destructive effects of the controlling teaching behaviour in this study. Students' regulation types expressed by the RAI-value (SRQ; compare Ryan & Connell, 1989) and documented at the beginning of this study indicate that students felt sparsely autonomous in regular biology coursework. The unfamiliar learning situation with living animals fostered positive motivation qualities. Controlling teaching behaviour presumably did not affect this positive motivation strongly enough to have an effect on the scale *interest/enjoyment.* The relatively low values of the students in the C-treatment for the subscales *pressure/tension* could be further evidence for this assumption. A possible explanation might be that the implemented controlling teaching behaviour in this study hardly differed from the teacher behaviour in biology lessons, as teachers are more inclined to act in a controlling manner (Martinek, 2010). The subscale *interest/enjoyment* revealed no significant differences even when students of both treatments differed in the negative predictor and two out of three positive predictors at both measuring times. The first hypothesis that autonomy-supportive teaching behaviour fostered intrinsic motivation was supported to some extent. The second hypothesis proposed that autonomy-support was associated with a higher flow-experience in comparison to the controlling condition as shown by the higher values in the FSS at both measuring times. Kowal and Fortier (1999) found that flow-experience not only depended on *perceived autonomy* but also on the subject groups' *perceived competence*. Values for the *perceived choice* and *perceived competence* subscales in our study were distinctly lower in the controlling treatment group than in the autonomy-supported group in study 1 (living animals). Beyond that, the interruption of students' activity caused by controlling teaching behaviour probably affected the major components of flow-experience (fluency of performance and absorption by activity) negatively. Autonomous and independent goal setting in the autonomy-supportive treatment possibly fostered concentration on essential contents, thus resulting in a more immersive flow-experience. For Csikszentmihalyi (1977), flow-experience is the ultimate form of intrinsic motivation. Consequently, autonomy-support seems to be appropriate to fostering the positive qualities of experience in biological learning content when living harvest mice are used in class.

Study 2 (video sequences) investigated the effects of autonomy-supportive teaching behaviour on students' positive qualities of experience when less interesting types of presentation were used. It was expected that autonomy-supportive teaching behaviour would foster internalisation and the associated self-regulated forms of motivation. Interpretation of the PSD questionnaire revealed that autonomy-supported students had experienced more autonomy than students of C-treatment at both measuring times. The operationalisation of autonomy-support and control succeeded. At the same time, teacher-dependent effects were revealed by measuring perceived autonomy in the subscales *perceived choice* and *pressure/tension*, as well as in the FSS in the first lesson. These qualities of experience seem not to be independent of the teacher when less interesting types of presentation are applied. Autonomy-experience, as well as intrinsic motivation, has been argued to foster flow-experience (Kowal & Fortier, 1999). Due to the interdependence of these constructs, it should be no surprise that a teacher-dependent effect on perceived autonomy can lead to the positive effects of motivation and flow-experience.

Data from the A-IMI revealed that autonomy-supported students felt more competent and less *pressure/tension* than those of the controlling treatment at both measuring times. Significant differences regarding *perceived choice* in favour of the autonomy-supported students appeared only at the second measuring time. According to Shernoff, Csikszentmihalyi, Schneider, and Shernoff (2003), watching video sequences provides little space for autonomous and active engagement with the learning content. The teaching unit with the video sequences might have offered choices to the students that were perceived as being of minor importance. The subscale *interest/enjoyment* revealed no significant difference between students of the autonomy-supportive and the controlling treatment for either measuring time. The relatively high values in this subscale of the A-IMI are perhaps attributable to the unfamiliar learning situation offered by the unknown teacher and the use of video sequences. Video sequences are seldom used in contrast to other lesson-dominating presentations such as textbooks (Schneider et al., 2012), even if students work with computers and watch video sequences in their private environment almost daily (Arnold & Weber, 2013). It may be the case that the use of this type of presentation in regular biology education was perceived as a relative novelty (Berlyne, 1951). Berlyne (1951) describes situations that deploy an established medium in a rather unfamiliar context as novelty situations. Novelty situations can be associated with higher *interest/enjoyment* (Reeve, 1989). The teaching behaviours in this study presumably differed minimally from normal biology education. The familiar controlling teaching behaviour has already been shown in the slightly positive RAI-values. This behaviour was probably insufficient to negatively affect the students' *interest/enjoyment* in the controlling treatment.

The FSS also revealed an ambiguous overall picture. At the first measuring time, values of flow-experience were significantly higher in the autonomy-supportive treatment than in the controlling treatment, whereas no differences could be detected at the second measuring time. These findings might be attributable to the different types of lessons at both measuring times. At the first measuring time, students were working on the learning content in small groups whereas those at the second measuring time were in plenum. Lessons in plenum are perceived as more heteronomous in contrast to group work (Marks, 2000). Furthermore, the work in plenum in comparison to group work allows fewer opportunities to interact with each other. It might be that the autonomy-supportive teaching behaviour was insufficient to minimise the students' feelings of heteronomy associated with traditional teaching approaches at the second measuring time.

Summary consideration of both studies indicates that the motivational effects of autonomy-supportive teaching behaviour seem to be dependent on the type of presentation to some extent. Autonomy-supportive and controlling teaching behaviour were equally operationalised and implemented in both studies. Nevertheless, distinctly higher effect sizes were measured in study 1 (living animals) compared to study 2 (video sequences) with the exception of *perceived choice* at the second measuring time and the subscale *pressure/tension* at both measuring times. It is conceivable that the operationalised autonomy-supportive teaching behaviour was insufficient to support the process of internalisation in study 2 (video sequences) during the time given for the intervention. Our findings give only weak, if any, evidence for the internalisation process (Deci & Ryan, 1985). The situation is different for the undermining process. The results of this study indicate an undermining process due to controlling teaching behaviour in biology lessons. Students of the controlling treatment perceived distinctly less autonomy and fewer choices, felt less competent and reported a distinctly lower flow-experience than students in A-treatment when interesting types of presentation were used. The current study consequently suggests that sole use of interesting types of presentation, such as living animals, constitutes no assurance for intrinsically motivated students. Data from study 1 illustrate this situation. Furthermore, it was shown that autonomy-support did not operate equally with all types of presentation, as shown by data from study 2. Autonomy-supportive teaching behaviour affected the quality of motivation and flow-experience more positively than controlling teaching behaviour, although findings were not always consistent with theory. Deci, Eghrari, Patrick, and Leone's (1994) early laboratory studies indicate that subjects can be motivated to engage in less interesting learning content with autonomy-support, although practicability and the effects of autonomy-supportive teaching behaviour in regular biology education should be subject to further investigation due to these partly inconsistent findings. Furthermore, it should be investigated whether the long-term application of specific types of presentations lead to differences in *interest/enjoyment* between students treated with autonomy-supportive and controlling teaching behaviour, or if it causes complete internalisation and undermines the learning process, respectively.

Disclosure statement

No potential conflict of interest was reported by the authors.

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