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Perceived Autonomy Support and Student Motivation in Hybrid Biology Education: a Self-determination Theory Perspective

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Abstract

Literature on student motivation revealed that students could experience a decline in their motivation when they shift from on-campus to online education. Previous studies identified autonomy-supportive instruction as an important influencer of student motivation. The present cross-sectional study utilized the self-determination theory to investigate whether student motivation to learn biology and their perception of autonomy-supportive instruction differ between online and face-to-face biology. Further, it scrutinised whether perceived autonomy support predict student motivation in hybrid biology lessons, and whether the association between intrinsic motivation/amotivation and perceived autonomy support differ in face-to-face versus online settings. A convenient sample of 88 secondary students who study three biology subjects in hybrid learning environment, was employed. The results showed that student motivation and their perception of autonomy support were different in online biology, compared to practicums. Also, perceived autonomy support was found to predict both intrinsic motivation and amotivation of students in the online and face-to-face biology. The effect of perceived autonomy support on intrinsic motivation differed between online and face-to-face biology. However, the effect of perceived autonomy support on amotivation was the same in the two settings. These findings point to the benefits of providing autonomy-supportive instruction in hybrid learning in general, and in hybrid biology in particular.

keywords: Self-determination theory, online biology, FTF biology, motivation, autonomy support, hybrid education

Autonomy-supportive Instruction and Student Motivation in Hybrid Biology Education

The outbreak of the COVID-19 pandemic in December 2019 affected the world; it turned lives upside down and called for changes to many aspects of life. One essential aspect of a person's life that COVID-19 had an impact on was education. When the decision to close schools was made across the globe, many educators turned to online learning (OL), a part of hybrid education, as an alternative to face-to-face (FTF) education (UNICEF, 2020). Hybrid education is defined by Xiao (2020) as "a learning space where course content is delivered using a combination of conventional seminars and electronic communication tools" (Thorne, 2003, p. 1206). Although other non-STEM (science, technology, engineering, and mathematics) subjects (Cotner et al., 2017) were taught in fully online environments; biology, as part of the STEM education, is taught within hybrid environments. This could have resulted from the concerns that full online education may not be suitable for STEM subjects, which require hands-on experimentation in laboratories (Wladis et al., 2015). Thus, the current situation has left 1.2 billion students in 186 countries with no choice but to attend lessons on digital platforms and workspaces such as the Microsoft Teams (Li & Lalani, 2020).

The shift to hybrid education by high school instructors and more specifically by high school biology instructors can be detrimental to student motivation, which can, in turn, lead to the creation of negative attitudes toward the learning process (Afzal et al., 2010). In other words, a drop in student motivation can lead to decreased achievement and participation in educational activities (Zaccoletti et al., 2020). When student motivation in hybrid environments drops, instructional practices that can support it are needed. These practices can include supporting student autonomy, which improves learning and boosts students feelings of competence and support (Black & Deci, 2000). Reeve (2006) explains that autonomy-supportive environments "involve and nurture (rather than neglect and frustrate) students' psychological needs, personal interests, and integrated values" (p.228). The present study aimed to find out whether students experience a decline in their motivation when they learn biology online, compared to FTF, and whether autonomy support can buffer against the potential drop in student motivation.

Motivation in Self-determination Theory

Motivation refers to the force that moves the person towards a specific behavior or action. Student motivation has long gained the interest of educational researchers. An important work on this topic is Deci and Ryan's self-determination theory (SDT) (1985), which suggests that three basic psychological needs of students could be met to promote their motivation: autonomy, competence, and relatedness. The theory also provides a taxonomy of motivation based on a continuum that ranges from a state of no motivation to external regulation to intrinsic regulation, the latter of which holds a good degree of autonomy and self-regulation.

Amotivation

Amotivation is the absence of intrinsic and extrinsic motivation. Amotivated learners "do not perceive contingencies between outcomes and their own actions" (Vallerand et al., 1992, p. 1007). Instead, they attribute their behaviors to outside forces that they have no control over. Amotivation could also present a state of having no intentions to engage in a certain behavior.

Extrinsic Motivation

Learners who are extrinsically motivated achieve for the sake of outside factors that guide their behaviors and not because they are particularly interested in the action of learning. According to Deci and Ryan (1985), extrinsic motivation means that the person behaves in a certain way because it leads to a "separable outcome".

Intrinsic Motivation

According to Deci and Ryan (2020), intrinsic motivation "pertains to activities done for their own sake, or for their inherent interest and enjoyment" (p. 2). When learners are intrinsically motivated, they tend to invest in a specific domain because they have an interest and enjoy learning about it. Previous research indicates that student intrinsic motivation toward learning biology (as part of science) declines through grade levels.

Student Motivation in OL

Student motivation in OL is not of less importance than that in the FTF setting. Rather, OL requires students to undertake greater responsibility in the learning process, compared to FTF education. The motivation of students plays an important role in their achievement, and motivating students is one of the challenges that educators face in OL (Stark, 2019). Previous studies suggested that lack of student motivation was the main reason behind attrition in OL (Kim & Frick, 2011).

Although students in OL can feel isolated, they need to manage their own learning, and they miss the timely feedback from their instructor, some empirical studies, however, suggested positive correlation between student motivation and OL. Beluce and Oliveira (2015) employed a sample of 572 Brazilian students who enrolled in higher education courses, to investigate their motivation in virtual learning environments (VLEs). They found that a considerable number of participants perceived themselves to be intrinsically motivated for involvement in situations of learning proposed in VLEs.

Several comparative studies between student motivation in online and off-line education found that online students can be more intrinsically motivated than their FTF counterparts (Hartnett, 2016). Intrinsic motivation has been identified as one of the important characteristics of learners who choose to learn online. This is because OL provides opportunities of self-control, competence, and challenge which foster student intrinsic motivation (Hartnett, 2016).

Student Motivation in Biology Lessons

Biological knowledge plays an important role in most aspects of human life. For students to gain this knowledge in biology lessons, they must be motivated to learn (Ekici, 2010; Shihusa et al., 2009). Biology lessons in high schools consist of a theoretical portion in which students learn the theories behind this science and instructors explain textbooks, and practicums in which they apply these theories in practice and instructors guide them through in-person lab experiments. As a result of school closure caused by COVID-19, biology lessons have begun to be offered in hybrid settings. Theories are taught online, and practicums are held on campus so that students can apply what they have learned under the physical supervision of their instructors. Thus, the present study aimed to investigate students' motivation and their perception of teachers' autonomy support in biology classrooms in particular.

Several empirical studies addressed the differences in student intrinsic motivation across multiple subjects. For example, Gaspard et al (2017) examined student motivation and value beliefs in five subjects (English, physics, biology, German, and math). They suggested that student intrinsic value which has a close overlap with intrinsic motivation (Eccles, 2005), was relatively high in biology. Thus, the present study could extend Gaspard et al.'s findings to the context of hybrid learning and further investigate variations of student motivation to learn biology and their perceptions of autonomy-supportive practices in such a context.

The motivation of high school students was found to positively correlate with their achievement in science (Chow & Jong, 2013). Thus, science serves as an advantageous field in which studies on motivation could be conducted. Science is a complicated field of knowledge that requires complex models to be learned and is rarely taught in distanced settings (Hallyburton & Lunsford, 2013). However, the way biology (as part of science) chimes in with hybrid environments, makes it an interesting field of research.

Autonomy-Supportive Learning Environments

Autonomy which refers to the person's desire to be the origin of their behavior (Vlachopoulos & Michailidou, 2006), can be supported in a learning environment that nurtures students' psychological needs (Niemiec & Ryan, 2009; Reeve, 2006). The correlation between perceived autonomy support and the three types of student motivation has long been the focus of researchers’ attention. Autonomy support was found to lead to students’ more self-determined forms of motivation (Reeve, 2008; Hartnett, 2016).

The effect of students’ perceptions of autonomy-supportive teaching on their intrinsic motivation to learn was examined in several studies. For example, Black & Deci (2000) investigated 380 students’ course-specific self-regulation and their perceptions of their instructors’ autonomy support. In their cross-sectional study, Sosic-Vasic et al. (2015) investigated the interplay of the motivation of 208 students from different school types and their teachers’ autonomy support. Also, Bieg et al. (2011) conducted a cross-sectional study on 1195 8^{th}-grade students and 48 teachers, and they used multi-level analyses to test the prediction of student intrinsic motivation based on their perception of teachers’ autonomy support. Further, Stroet et al. (2013) reviewed 71 empirical studies conducted since 1990 on the effects of need-supportive teaching on early adolescents’ motivation. They found that in most studies student perceptions of autonomy support were used to measure need-supportive teaching. All the previously-mentioned studies reported a positive correlation between perceived autonomy support and student intrinsic motivation. This is because autonomy support satisfies one of the three psychological needs: *autonomy*, and facilitates the two other needs: competence and relatedness. In their article, Lee et al. (2015) discussed the benefits of autonomy support as a strategy to enhance online students’ intrinsic motivation and engagement. They introduced autonomy-supporting strategies as a method to help instructors to enhance students’ malleable engagement by supporting them to develop more autonomous levels of motivation, which in turn can lead to greater success in online courses.

Few studies investigated the influence of perceived autonomy support on student extrinsic motivation and amotivation. Gillet et al. (2010), for instance, proposed and tested a model which posited that coaches' autonomy support can facilitate 101 athletes' self-determined motivation toward a sport activity. The results obtained from the structural equation modeling analyses provided support for their hypothesized model and reported no association between coaches autonomy-supportive practices and athlete’s extrinsic motivation and amotivation. Moreover, Pelletier et al. (2001) used a prospective 3-wave design to test a model that incorporates perceptions of coaches’ interpersonal behaviours, five forms of regulation (intrinsic, identified, introjected, external, and amotivation), and persistence of 369 competitive swimmers. Their results revealed that the perception of control and the absence of autonomy support could be associated with swimmers’ extrinsic motivation.

Previous literature outlines several approaches to autonomy-supportive environments both in FTF and online settings. However, the present study focused on four of these approaches which were illustrated by Reeve (2006), as follows:

Providing Choices

Teachers provide students with options and encourage their sense of choice-making (Reeve, 2011). Teachers do not force students to participate in certain activities; they rather encourage students to participate out of their own volition (Kusurkar et al., 2011). The methodological diversity of biology calls for the selection of proper study and work methods. This, in turn, can promote provision of choices for students during biology lessons (Großmann & Wilde, 2018). According to SDT, this can help students feel autonomous and stimulate their intrinsic motivation (Patall et al., 2010).

Providing Meaningful Rationales

Teachers provide students with “verbal explanations to help them understand why self-regulation of the activity would have personal utility” (Núñez & León, 2015, p. 277). When the value of an unappealing task is properly illustrated to students, it allows for an internalization process of this value (Reeve et al., 2002; Reeve, 2006). Dutch secondary schools provide flexibility in the application of STEM curriculum (Educational Designer, 2019). The content of the curriculum and the context in which biology is taught, allow for the provision of rationales. This can help students link the personal relevance to the subject.

Nurturing Student Interest

According to the interest theory, when teachers create learning activities that can be perceived as relevant to student interest, the psychological state of interest is automatically triggered (Reeve, 2006; Tsai et al., 2008). This can stimulate student intrinsic motivation and self-determined types of extrinsic motivation. It addresses the issue of introducing new learning tasks to students, which can support student initiative on tasks. Biology includes topics that are less interesting for students; however, utilizing other approaches to autonomy support could compensate for low topic interest of students (Großmann & Wilde, 2018).

Acknowledging and Accepting Student Negative Affect

Teachers show sensitivity and tolerance when students express their concerns and negative emotionality in response to undesirable tasks (Reeve, 2016). Biology teachers can acknowledge that some tasks would contradict student interests. This can help teachers resolve the problem of conflicts between what they want their students to do and what students themselves want to do (Reeve, 2006). Negative affect of students could intervene in their learning, therefore, it is important to address student negative affect as a step to motivationally prepare students to the coming lessons.

Basic Psychological Needs

When considered in the educational setting, SDT shows that learners have three basic needs which, if satisfied, provide better psychological well-being. Student need for autonomy refers to the experience of self-determination and volition (Deci & Ryan, 2002; Evelein et al., 2008). This need can be satisfied when students perceive that they are the origin of their behaviours, choices and decisions, and that they are acting in accordance with their integrated sense of self. The need for competence reflects students' willingness to feel competent and to influence and control their environments (Evelein et al., 2008). This need can be fulfilled when students get a sense of mastery via effective interaction within their environment. The need for relatedness indicates students longingness to experience positive relations with their teachers and peers. This need can be satisfied when students feel attached to and respected by significant others (Adie et al., 2008). Thus, satisfaction of these psychological needs can enhance student motivation and psychological well-being (Niemiec & Ryan, 2009).

Previous research reported that the three psychological needs can mediate the path from autonomy support to motivation. Also, a bidirectional correlation was found between need satisfaction and perceived autonomy support. For example, Souesme et al. (2016) who collected sociodemographic data from 100 participants, revealed that patients with lower need satisfaction have lower levels of perceived autonomy support. Lopez et al. (2012) assigned 669 young athletes to fill in the intrinsic motivation inventory. They found that perceived coach autonomy support predict the satisfaction of the psychological needs of the young athletes. Therefore, it was feasible to include the psychological needs of biology students as control variables in the present study.

The Present Study

The present study aimed to investigate whether high school student intrinsic, extrinsic, and amotivation; as well as their perception of biology instructors' autonomy support would be different in online versus FTF biology. It further scrutinized if perceived autonomy support alongside psychological needs, could predict the three types of student motivation in hybrid biology lessons. Finally, it tested whether the effect of perceived autonomy support on student motivation could differ between online and FTF biology. The following research questions were formulated:

RQ1. How do high school student motivation and perceived autonomy support differ between online and FTF biology lessons?

RQ2. To what extent do high school students' perceptions of their teachers' autonomy support influence students' intrinsic, extrinsic, and amotivation in hybrid biology lessons?

RQ3. How does the association between perceived autonomy support and student motivation differ in online versus FTF settings?

This study hypothesized that the three types of student motivation and student perception of their biology instructors' autonomy support could be different in online biology compared to FTF biology (*Hypothesis 1*). Additionally, it hypothesized that perceived autonomy support could predict high school students' intrinsic motivation to learn in biology lessons when hybrid teaching is offered (*Hypothesis 2A)*. It also supposed no influence of perceived autonomy support on student extrinsic motivation or amotivation (*Hypothesis 2B).* Furthermore, it expected that the physical presence of both teachers and students in a classroom, where communication is smoother and body language is visible, provides a different type of support than that offered in an online setting. Accordingly, it was expected that students could perceive their teachers' autonomy-supportive behavior differently in FTF education than in online education, which could result in a different effect of perceived autonomy support on student motivation between the two settings (*Hypothesis 3*).

Methods

Research Design

This paper presents a testing quantitative survey research with a cross-sectional design that "provides a 'snapshot' of the outcome and the characteristics associated with it, at a specific point in time" (Levin, 2006, p. 24).

Participants

This study employs convenient sampling, a total of 88 students participated. They followed secondary vocational education which represents a Dutch branch of education that prepares students for a wide range of occupations through an up-to-four-year program, from franchise manager to mechanic or nursing assistant. The students aged between 17–29 years (*M* = 19.4 , *SD* = 1.9). Only 63 students completed the whole questionnaire; 81% provided demographic data; and of the 88 students, 17 students did not provide answers to all online items and 21 students did not provide answers to all FTF items. A rate of 68.1% of the participants identified themselves as females and 31.9% as males. Seven students reported using other languages than Dutch at home (i.e. Italian, Berber, Turkish, English and Arabic). Students received a combination of online and FTF biology education. Instructors offered online teaching sessions throughout the week and they provided study materials on Blackboard. Practicums were held on campus because students required direct supervision from an instructor in the application of their knowledge.

Sample Size Estimation

A statistical power analysis was performed to estimate the sample size. The three constructs of motivation were used as dependent variables and the four constructs of autonomy support were used as predictors. With an alpha = .05, and power = 0.80, the projected sample size on GPower (3.1) was $N = 60$.

Procedures and Ethical Considerations

Conducting the present research at the concerned high school was permitted by the school administrator. The students received the information letter that illustrated the purpose and procedure of the study before they completed the questionnaire. They were asked if they had the interest to participate in the study after informing them that their participation would be anonymous. Thus, the biology instructors would not be informed of the responses that the students provided. The students also consented their participation in the study right before data collection. The data collection process occurred on 24 March in one session, where the two contexts were considered. The students received a link to the questionnaire on LimeSurvey from their instructor after their biology lesson. They used 30 minutes to complete the questionnaire which was administered in Dutch. The biology instructor did not intervene in the process or observe the students' responses. The responses were given anonymously to protect participants' privacy.

Measures

The present study utilized self-report questionnaire. The participants were asked to provide information about their age, gender, class, language they speak at home, and background. The questionnaire included control variables to measure the basic psychological needs of students in online and FTF biology (i.e. autonomy, competence, and relatedness to their biology teacher). The baseline variables were student intrinsic, extrinsic, and amotivation and their perception of the biology instructors' autonomy-supportive practices in online and FTF lessons. All numeric items could be answered on a 4-point Likert scale ranging from 1 (never true) to 4 (always true). Fourteen negatively-worded items were recoded[1]. The structure of the scales was assessed using an Exploratory Factor Analysis (EFA), whereby the eigenvalue of each scale was expected to be higher than 1, communality to be greater than .4, 10% of the variance to be explained, and a factor loading higher than .30 was observed. As a rule of thumb, an item could be assigned to a factor when the estimated standardized factor loading is between .30 and .40 (Schmitt & Sass, 2011). Then the reliability of the variables was assessed according to the COTAN criteria, where Cronbach's alpha ≥ .7 and item rest correlation > .30 are observed.

Control Variables Measure

Twenty items adapted from a previous study[2] were used to measure the student basic needs in online and FTF biology lessons. Four items (×2 settings) measured student relatedness

[1] OL relatedness 2, OL relatedness 3, OL providing choices 2, OL amotivation 1, OL amotivation 2, OL amotivation 3, OL amotivation 4, FTF relatedness 2, FTF relatedness 3, FTF providing choices 2, FTF amotivation 1, FTF amotivation 2, FTF amotivation 3, and FTF amotivation 4.

[2] **Need Satisfaction** - Flunger, B., Pretsch, J., Schmitt, M., & Ludwig, P. (2013). The role of explicit need strength for emotions during learning. *Learning and Individual Differences*, *23*, 241-248.

to biology instructors. An example item is “Tijdens online biologieles en bij mijn biologie leraar, voel ik me geaccepteerd”. Three items measured student autonomy (×2 settings). An example item is “ik kan zelf bepalen hoe ik aan een online opdracht werk”. Three items (×2 settings) measured student competence. An example item is “ik begrijp de moeilijke online opdrachten ook goed”. (All items are provided in Appendix D).

Exploratory Factor Analysis for Psychological Needs. EFA with an Oblimin rotation was executed to test the structure of the psychological needs instrument. The results indicated that three factors with an eigenvalue above 1.00 were identified in each setting. All items in the two settings had communalities > .4. Items of the online setting had factor loadings >.30 on the factor they originally belonged to. Several cross loadings in FTF were observed (Table 1 - Appendix E), which led to different structures in the two settings. Therefore, a partial CFA was conducted and different solutions were compared (IBM Support, 2018). Three factors were forced with an ML estimation, and it was clear that items Relatedness 1 and 2 (in online and FTF) had low communalities <.4. Consequently, the items were eliminated and EFA was run again. The results indicated the same clear structure in the two settings this time (Figure 1 - Appendix E).

Reliability Test. Cronbach’s alpha was good ($\alpha \geq .80$) for the three psychological needs in online and FTF, indicating sufficient internal consistency (Table 2 - Appendix E).

Motivation Measure

Twenty-four items were used to measure student intrinsic, extrinsic, and amotivation in online and FTF biology. Items for intrinsic and extrinsic motivation were adapted from the "Academic Self-regulation Questionnaire" (SRQ-A), which was written by Ryan and Connell (1989). The items were translated by Sierens et al. (2009). Amotivation items were adapted from the Academic Amotivation Inventory Scale (Legault et al., 2006). All items were manipulated to suit the concerned biology courses in the hybrid learning environment. Example items are : “Ik doe mijn best voor de online biologieles omdat het leuk is" for intrinsic motivation, "Ik doe mijn best voor de biologiepraktijkles omdat ik dit moet doen" for extrinsic motivation, and "Ik zie geen reden om biologie online te leren" for amotivation. (See Appendix D)

Exploratory Factor Analysis for Motivation. EFA with an oblimin rotation was executed to test the structure of motivation scales both in online and FTF settings. Results of the online setting revealed that four factors had an eigenvalue > 1.0, and that five items loaded at least on two factors. One problematic item "online amotivation 2" was dropped because it loaded on three factors and deleting it would improve the structure. EFA was executed again; results showed that three factors had an eigenvalue > 1.0. Communalities of all items were > .4, indicating that the three extracted factors explained more of the variance of the items. Results of the FTF setting showed that three factors had an eigenvalue > 1.0. The most items loaded high on their original factors, except for items amotivation 1 and 2. They loaded with almost equal factor loadings on two factors; thus, they were dropped. EFA was run again and the structure of the scales improved (Table 3 – Appendix E).

Reliability Test. The reliability test showed that the internal consistency of the six variables was good: intrinsic motivation, online $\alpha = .81$ and FTF $\alpha = .91$; extrinsic motivation, online $\alpha = .80$ and FTF $\alpha = .83$; and amotivation, online $\alpha = 1.0$ and FTF $\alpha = 1.0$. Item-rest correlations of all items were > .30.

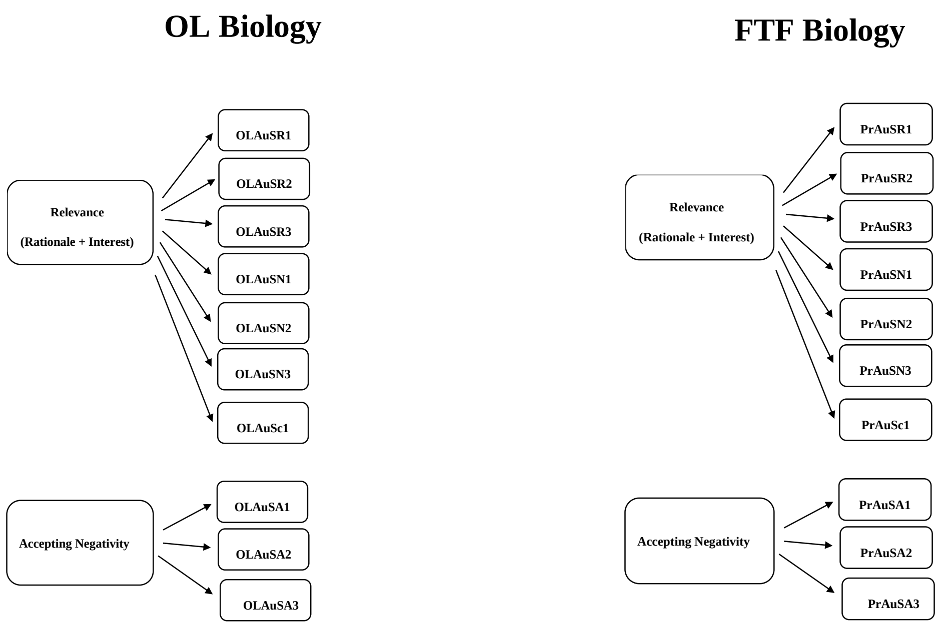
Perceived Autonomy Support Measure

Students' perception of their biology instructors autonomy support was measured with a questionnaire (Flunger et al., under review) that was developed on the basis of a new questionnaire from Aelterman et al. (2019). Items of the questionnaire were manipulated to suit the online and FTF biology lessons. Perceived autonomy support consisted of four scales (×2 settings), each of them was measured with three items (Appendix D).

Exploratory Factor Analysis for Perceived Autonomy Support. The literature on autonomy support and the source expected that perceived autonomy support can include four factors. Perceived autonomy support was measured with the exact same items in the online and FTF settings, only the wording of the items was manipulated to fit in each setting. Therefore, the structure of the scales was expected to be the same in the two settings. EFA with Oblimin rotation was conducted in one setting (online) (Table 4, Appendix E). Based on the solution, a partial CFA was investigated with the second setting (FTF), in order to enable the comparability of the two solutions (IBM Support, 2018). A partial CFA can be conducted in SPSS through a number of steps. First the solution of an EFA in one setting was inspected, then a solution with a certain amount of factors was decided, and finally SPSS was allowed to estimate the same amount of factors in the second setting. Hence, the solution can also be assessed and its correspondence with the first EFA can be evaluated. Figure 1 shows the new structure of autonomy support in the online and FTF settings.

Figure 1

New Structure of Perceived Autonomy Support in OL and FTF Biology



Reliability Test. The reliability test showed that Cronbach's alpha was high for online Relevance, α = .84 and Accepting negative affect, α = .82, indicating sufficient internal consistency. Cronbach's alpha was also high for FTF Relevance, α = .89 and Accepting negative affect, α = .85 , indicating good internal consistency (Table 5 – Appendix E).

Data Analysis

Data analysis was conducted by means of IBM SPSS (25), with a significance level of .05.

Paired Samples T-Test

Five t-tests were executed by means of SPSS to investigate whether student motivation and autonomy support significantly differ in online versus FTF biology. The difference between computed mean scores of the three types of motivation in online versus FTF lessons, as well as the difference between the mean scores of the two components of perceived autonomy support were calculated. During data exploration, assumptions of the t-tests were checked: outliers detection, normality, homogeneity of variance, sample size, and scale of measurement.

Multiple Regression Analysis

To answer RQ2, six multiple regression analyses were performed: three analyses in the online setting and three analyses in the FTF setting. This could investigate whether perceived autonomy support predicted the three types of student motivation. A separate regression analysis was performed for each type of motivation, with the computed mean score of one type of motivation as a dependent variable and the mean scores of the two components of perceived autonomy support as independent variables. Mean scores of the psychological needs were used as control variables.

Testing the Assumptions of Multiple Regression. For each MLR a number of assumptions was tested: normality, linearity, normal distribution of residuals, homoscedasticity, and multicollinearity. Statistical analyses and visual detection of p-p plots and scatter plots were used to examine the assumptions.

Paternoster Test

In order to answer RQ3, the significance of the difference between regression coefficients of the baseline variables in online and FTF biology was determined (Paternoster et al., 1998) (see Figure 2). Regression coefficients and coefficient variances which were obtained from the previously-executed six MLR analyses, were used to calculate the *z* scores. Formula's which were approved as appropriate by Paternoster and colleagues, were employed. Finally, the *p* value from the *z* scores was calculated to test the significance of the difference.

Figure 2

The Correct Formula for the Statistical Test according to Paternoster Et AL. (1998)

$$Z = \frac{b_1 - b_2}{\sqrt{SEb_1^2 + SEb_2^2}}.$$

Missing Values

The percentage of missing values was 23.9% at the maximum level, because different percentages of missing values were detected throughout data exploration. This could lead to reduced data and could affect the statistical power of the study, thereby leading to less reliable results. This issue was addressed by means of listwise deletion because this method is commonly used in SPSS.

Results

Descriptive Statistics

Descriptive statistics and correlations of student intrinsic, extrinsic, and amotivation and of their perceptions of autonomy support and psychological needs in online and FTF biology are summarized in Table 1.

Research Question 1

Paired-samples t-tests were conducted to determine whether student motivation and perceived autonomy support differed between online and FTF biology lessons. The results for student motivation showed that students had lower intrinsic motivation in the online biology lessons (M = 2.6, SD = .62) than in the FTF biology lessons (M = 3.3, SD = .69), this difference was significant, $t(66) = -9.4$, $p < .001$. Also, students had lower extrinsic motivation in the online biology lessons (M = 2.6, SD = .69) than in the FTF biology lessons (M = 2.9, SD = .71), this difference was statistically significant, $t(66) = -3.7$, $p < .001$. Also, students were less a-motivated in the online biology lessons (M = 3.1, SD = .68) than in the FTF biology lessons (M = 3.6, SD = .63), this difference was statistically significant, $t(66) = -6.9$, $p < .001$.

The results for perceived autonomy support indicated that relevance was lower in online (M = 2.7, SD = .53), compared to FTF biology (M = 3.1, SD = .59). The difference between the two settings was significant, $t(68) = -.6.2$, $p < .001$. Also, acceptance of negative affect was lower in online (M = 2.5, SD = .77), compared to FTF biology lessons (M = 2.9, SD = .77). The difference between the two settings was found to be significant, $t(66) = -5.5$, $p < .001$.

Research Question 2

Prior to the MRL analyses which were conducted to answer RQ2, several assumptions were assessed. Scatterplots showed that the relationship between the dependent and independent variables[3] was linear. Shapiro-Wilk test showed that the assumption of normal distribution of the dependent variables was violated in the six MLRs. The assumption of multicollinearity was met because analyses of collinearity statistics indicated that VIF scores were well below 10, and

[3] Each analysis included the two components of perceived autonomy support in online OR FTF biology lessons as independent variables and one type of motivation as a dependent variable. The three scales of psychological needs were included as control variables.

Table 1

Mean Scores, Standard Deviations, and Correlation Coefficients of the Baseline and Control Variables

Variable	*N*	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Online relevance	75	2.7	.56	-															
2. Online accepting negative affect	73	2.5	.79	.48**	-														
3. Online intrinsic motivation	71	2.6	.65	.47**	.33**	-													
4. Online extrinsic motivation	71	2.6	.69	.09	.02	-.14	-												
5. Online amotivation	71	3.1	.68	.44**	.24*	.56**	-.02	-											
6. FTF relevance	69	3.1	.60	.69**	.24*	.43**	.09	.41**	-										
7. FTF accepting negative affect	67	3.0	.77	.42**	.61**	.33**	.07	.30*	.50**	-									
8. FTF intrinsic motivation	67	3.3	.69	.51**	.24	.53**	.11	.44**	.75**	.43**	-								
9. FTF extrinsic motivation	67	2.9	.71	.13	.00	-.03	.53**	.07	-.02	-.02	.08	-							
10. FTF amotivation	67	3.6	.63	.38**	.08	.13	.16	.51**	.56**	.25**	.49**	.11	-						
11. Online relatedness	75	3.4	.73	.23*	.50**	.12	.09	.36**	.15	.42**	.02	-.05	.22	-					
12. Online competence	75	2.6	.68	.21	.14	.37**	-.14	.38**	.16	.07	.02	-.15	.08	.29**	-				
13. Online autonomy	75	2.9	.77	.24*	.16	.47	-.15	.41**	.28**	.11	.19	.02	.18	.11	.45**	-			
14. FTF relatedness	68	3.3	.69	.45**	.33**	.30*	.05	.56**	.48**	.53**	.42**	-.01	.55**	.59**	.23	.24*	-		
15. FTF competence	68	3.1	.62	.35**	.11	.32**	-.18	.38**	.42**	.19	.26*	-.22	.22	.13	.37**	.37**	.44**	-	
16. FTF autonomy	68	2.8	.69	.50**	.32**	.28*	.10	.28*	.55**	.25*	.34**	-.11	.34**	.30**	.42**	.25*	.35**	.85**	-

Note. * correlation is significant at the .05 level (2-tailed), ** correlation is significant at the .01 level (2-tailed) tolerance scores were above 0.2. Further, plots of standardised residuals vs standardised predicted values showed no obvious signs of funnelling, suggesting that the assumption of homoscedasticity was met in all MLRs. Additionally, Cook's Distance values were all under 1, suggesting no outliers in the data. Finally, the P-P plots for the models suggested that the assumption of normality of the residuals may have been violated. However, as only extreme deviations from normality were likely to have a significant impact on the findings, the results would probably still be valid.

The Effect of Perceived Autonomy Support on Student Intrinsic Motivation

Two MLR analyses were calculated to examine whether perceived autonomy support and student psychological needs predict student intrinsic motivation in hybrid biology. In the online setting, the overall model had statistically significant positive effect on student intrinsic motivation, $R^2 = .35$, $F(5, 63) = 6.69$, $p < .001$. According to Cohen's (1988) standards of interpretation, the effect can be seen as large. However, only relevance and autonomy were significant predictors in the model ($\beta_{relevance} = .32$, $p_{relevance} = .03$; $\beta_{autonomy} = .27$, $p_{autonomy} = .03$) (Table 2). In the FTF setting, perceived autonomy support had statistically significant positive effect on student intrinsic motivation, $R^2 = .61$, $F(5, 57) = 17.9$, $p < .001$. According to Cohen's (1988) standards of interpretation, the effect can be seen as large. Only FTF relevance had significantly positive effect ($\beta_{relevance} = .94$, $p_{relevance} < .001$) (Table 2).

The Effect of Perceived Autonomy Support on Student Extrinsic Motivation

Two multiple regressions were carried out to investigate whether students' perception of autonomy support and their psychological needs in hybrid biology could predict their extrinsic motivation. Results showed a non-significant regression equation in online biology, $R^2 = .08$, $F(5, 61) = 1.09$, $p = .38$. Thus, perceived autonomy support in online biology did not predict student extrinsic motivation (Table 2). Also, results of the FTF setting indicated that perceived autonomy support does not predict student extrinsic motivation, $R^2 = .06$, $F(5, 57) = .73$, $p = .61$.

Thus, FTF autonomy support in student perspective did not predict their extrinsic motivation (Table 2).

The Effect of Autonomy Support on Student Amotivation

Two MLR analyses were calculated to predict amotivation based on perceived autonomy support and student psychological needs in hybrid biology. Two statistically significant Models were found. First, the model of perceived autonomy support in online biology had significant positive effect on student amotivation, $R^2 = .38$, $F(5, 63) = 7.56$, $p < .001$. All variables had statistically significant effect in the model except for competence and accepting negative affect (Table 2). Second, the model of perceived autonomy support in the FTF setting had statistically significant positive effect on amotivation, $R^2 = .44$, $F(5, 57) = 8.88$, $p < .001$. According to Cohen's (1988) standards of interpretation, the effect can be seen as large. FTF relatedness and relevance had statistically significant positive contribution to the model ($\beta_{relevance} = .51$, $p_{relevance} < .01$; $\beta_{relatedness} = .42$, $p_{relatedness} < .001$).

Table 2

Regression Analysis Summary for Perceived Autonomy Support Predicting Student Intrinsic, Extrinsic, and Amotivation in Biology

	Online Biology						FTF Biology					
Predictors	Intrinsic Motivation		Extrinsic Motivation		Amotivation		Intrinsic Motivation		Extrinsic Motivation		Amotivation	
	SE	β	*SE*	β	*SE*	β	*SE*	β	*SE*	β	*SE*	β
Relevance	.15	.32*	.18	.25	.15	.41*	.13	.94**	.22	.10	.15	.51**
Negative affect	.10	.16	.14	-.07	.11	-.10	.09	-.03	.16	-.04	.11	.16
Perceived competence	.12	.16	.15	-.17	.12	.14	.12	-.01	.20	-.33	.13	-.18
Perceived autonomy	.03	.27*	.13	-.11	.10	.26*	.11	-.11	.18	-.01	.12	.05
Perceived relatedness	.11	-.11	.14	.16	.12	.28*	.10	.13	.17	.09	.11	.42**

Note. $R_{OL\ Intrinsic\ Motivation} = .59$, $R_{OL\ Extrinsic\ Motivation} = .29$, $R_{OL\ Amotivation} = .61$, $R_{FTF\ Intrinsic\ Motivation} = .78$, $R_{FTF\ Extrinsic\ Motivation} = .25$, $R_{FTF\ Amotivation} = .66$ (* $p < .05$, ** $p \leq .001$)

Research Question 3

Regression coefficients and standard errors obtained from the MLR analyses which were executed to answer RQ2, were used to calculate the *z* scores. By means of Excel (365), four *z* test formula's adopted from Paternoster et al. (1998), were calculated to reveal the difference in the associations between online and FTF biology. Then a Quick *p* value from *z* score calculator (Social Science Statistics, 2021) was used to check the significance of the scores. Extrinsic motivation was excluded from the test because multiple regressions showed non-significant prediction of student extrinsic motivation in online and FTF biology based on perceived autonomy support.

Two *z* tests were conducted to test whether the association between intrinsic motivation, and perceived autonomy support was different in online versus FTF biology. The results revealed that the difference in the association between intrinsic motivation and relevance was statistically significant, $z = 1.98$, $p = .02$. Additionally, the difference in the association between intrinsic motivation and accepting negative affect was statistically significant, $z = -4.59$, $p < .001$. Also, two *z* tests were calculated to test whether the association between amotivation and autonomy support is different in online versus FTF biology. The results showed that the difference in the association between amotivation and relevance was not significant, $z = -.49$, $p = .49$. Also, the difference in the association between amotivation and accepting expressions of negativity was not significant, $z = .42$, $p = .56$.

Discussion

The present study explored whether high school students' motivation and their perception of biology instructors' autonomy support differed between online and FTF biology. It examined if perceived autonomy support predicted student motivation in hybrid learning. The predictors considered were relevance and accepting negative affect. The outcome variables considered were student intrinsic, extrinsic, and amotivation both in online and FTF biology lessons. Also, the analyses included student psychological needs (according to the SDT) as control variables.

Moreover, this study investigated the variance in the association between perceived autonomy support and student motivation in online versus FTF biology. Thereby, differences between regression coefficients of the two correlations were spotted, then they were divided to the root sum score of the standard errors.

Research Question 1: the Difference between Online and FTF Biology in Student Motivation and Perceived Autonomy Support

The current study focused on the differences of student motivation and perceived autonomy support between online and FTF biology lessons. Previous research assumed that online students can be more intrinsically motivated than their on-campus counterparts because learning online requires students to obtain a good degree of intrinsic motivation and, at the same time, the nature of OL fosters student intrinsic motivation (Harandi, 2015; Hartnett, 2016). Thus, the current study assumed that student motivation and their perception of autonomy-supportive practices would differ between online and FTF biology (Hypothesis 1). The obtained results confirmed the first hypothesis. Based on the analysis of the data undertaken, it was possible to ascertain that a considerable number of students perceived themselves to be more motivated in biology practicums, compared to the online lessons. The three types of motivation and perceived autonomy support were found to be different in the two settings. However, intrinsic motivation was higher in FTF biology, and this contradicts the revised literature which suggested that OL intrinsic motivation is higher in OL. The sudden shift from on-campus education to OL as a consequence of the COVID-19 procedures could have caused the deterioration of student intrinsic motivation towards amotivation. Students may have missed the timely feedback of their instructors and the physical interaction with their classmates. The geographical distance between students and their biology instructors in the online biology could have created a feeling of isolation (lack of belongingness). This could explain why the participants to the current study seemed to thrive more in the FTF setting, compared to the online setting.

Research Question 2: the Predictive Effect of Autonomy Support on Student Motivation

Confirming the second hypothesis, the results showed that perceived autonomy support predicted student intrinsic motivation in online and FTF biology lessons. However, only relevance in online and FTF biology significantly contributed to the model. This could mean that students who perceive that their biology instructors can reinforce their interest and give verbal explanations of why biology assignments are important, grow better intrinsic motivation. Moreover, among the three psychological needs in each setting, only online autonomy predicted intrinsic motivation. This could indicate that students who are responsible for their learning and therefore feel autonomous (Kusurkar et al., 2011), are intrinsically motivated to learn biology in the online sessions. Previous research revealed that students who take greater responsibility and have better control of their progress, grow better intrinsic motivation (Schunk & Zimmerman, 1998; Artino, 2008).

These findings mirror the works of Assor et al. (2002), Bieg et al. (2011), Lee et al (2015), and Roth et al. (2007), indicating that the positive correlation between perceived autonomy support and student intrinsic motivation could be robust for student learning in virtual environments. To this end, the present study can suggest the inclusion of the principals of autonomy-supportive instructional practices in teacher education programs and staff development training courses for teachers.

When examining whether perceived autonomy support predicted student extrinsic motivation, none of the variables was found to predict extrinsic motivation in the two settings. Hence, in the current sample it was found that whether students perceive biology instructors as autonomy-supportive who boost their interest, provide them with rationales for learning biology, and accept their negative affect in online biology/practicums, their extrinsic motivation does not change. Even the control variables (i.e. competence, autonomy, relatedness) did not predict extrinsic motivation based on perceived autonomy support.

More interestingly, when the influence of perceived autonomy support on student amotivation in online and FTF biology was examined, significant positive equations could be found. Contrary to the predictions of SDT, the data partially failed to support hypothesis *2B*. In the online biology, the way students perceived their biology instructors' behaviors as rationale-providing and interest-boosting, positively predicted their amotivation to learn the subject. Also, students' feelings of autonomy and relatedness to their online biology instructors could positively predict their amotivation. In the FTF lessons, students' perceptions of biology instructors as to provide rationales on why biology is important to learn, and to nurture student interest in the subject, could positively predict their amotivation. Further, students' feeling of relatedness to the FTF biology instructors could positively predict their amotivation.

Possible explanation for this outcome could be approached from two perspectives. Firstly, the way students might have conceived their instructors' expressions and practices could be considered. Particularly, in the online lessons, misconceptions of teachers' behaviors could occur. Artino (2008) investigated the relations between students' motivational beliefs and their perceptions of the learning environment. He found a significant correlation between students perceptions and their motivational beliefs. This could explain the present study's results in that students could have perceived their instructors' actions in a way that was detrimental for their motivation to learn biology.

Secondly, the extent to which biology instructors made a conscious effort to enact their autonomy-supportive behaviours, can be considered particularly in the online lessons. Biology instructors could have lacked the skills of supporting students' autonomy in a virtual setting. Thus, the present study could have better employed teacher questionnaires to detect how biology instructors conceive themselves as autonomy-supportive. This would have helped to examine whether biology instructors provided adequate autonomy support to their students. Shen (2015) used the taxonomy of amotivation to study student amotivation and teacher autonomy support. He found that amotivation could be influenced by inadequate autonomy support.

Research Question 3: Differences in the Predictive Effect of Autonomy Support Across the Two Contexts

The data could partly support hypothesis 3. The results of the *z* tests showed that the difference of the association between intrinsic motivation and both relevance and accepting negative affect was significant in the online and FTF settings. This could mean that the effect of perceived autonomy support on student intrinsic motivation differs from online biology lessons to practicums. However, the difference of the association between amotivation, relevance, and accepting negative affect was statistically not significant. This could mean that student perception of autonomy support had a similar effect on their amotivation in the two settings.

Limitations

The present study had some limitations; for instance, the issue of missing data was faced. Only 71% of the participants answered all items of the questionnaire. Despite the fact that the GPower analysis indicated a sample size of 60 participants (ratio of 4.3:1), literature reported that the ratio should range from 5:1 to 10:1 (Reio & Shuck, 2015). This could mean that the ratio of this study was not satisfactory. One reason behind this could be the difficulties of remotely conducting research and reaching participants during the COVID-19 period. Further, generalizability of the findings could be better ensured if teacher questionnaires were employed. Thus, good insight of autonomy support from teacher perspective could be obtained. Also, the limitation of self-report studies needs to be considered. It is necessary to be alert to the possibility that the students may have provided answers which they judge to be more socially valued or that they would like to perform. Therefore, further qualitative investigation could refine the analysis and better understand the data obtained. Additionally, violating two MLR assumptions could be detrimental for the results. Given the small number of data points, MLR would be affected, resulting in potential misleading results.

Implications

The findings from the present study had some implications. They revealed that high-school students perceive their biology instructors' autonomy-supportive practices better in the FTF sessions. Therefore, these students grow higher intrinsic motivation in FTF biology, compared to their motivation in online biology lessons. Moreover, student perception of biology instructors' autonomy support in hybrid biology lessons was found to enhance student intrinsic motivation. This can highlight the importance of promoting autonomy-supportive practices in hybrid environments, and more specifically in online lessons where intrinsic motivation was found to be lower. Biology instructors can explicitly show their respect and acceptance of student individual interests, they can also give them verbal explanations on the importance of learning biology online.

Practical implications encourage the inclusion of autonomy-supportive skills in teacher educational programs and professional training courses. These skills could help teachers deliver the content of their subject in a way that supports students' autonomous motivation and more specifically, their autonomy need satisfaction in online learning. First, teachers would learn how to build their instruction in a way that creates opportunities for student engagement in biology lessons because they are interesting. Such instruction can boost students' intrinsic motivation by enabling them to motivate themselves (Reeve, 2016). Second, when addressing a topic that students would perceive as uninteresting, teachers need the skill of providing students with reasons (i.e. personal utility) behind asking them to undertake a particular course of action. Third, teachers can acknowledge students' negative affect by talking about it and then they can accept such affect and inform students that their affect is understandable. This skill, in particular, is important because the problem of student negative affect is difficult to resolve and it influences the teacher-student bi-literal relationship.

Conclusion

Moving beyond studies that simply assess student motivation and notwithstanding the current study’s limitations, the findings provide educators and policy makers with an insight into the ways to create learning environments that support students’ autonomous motivation in hybrid courses. Future research can continue to explore the correlation between autonomy-supportive instruction and student motivation. It can, furthermore, investigate which instructional interventions can be designed to positively impact students’ motivation in hybrid environments.

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Appendix A

Information Letter

Universiteit Utrecht

Informatiebrief deelname aan onderwijs wetenschappelijk onderzoek

Autonomy Support and Motivation of High-school Students: a Self-determination Theory Perspective

15 Maart 2021

Beste Student,

Je neemt deel aan het onderzoek "Autonomy Support and Motivation of High-school Students: a Self-determination Theory Perspective" van de Universiteit Utrecht, onder leiding van Dr. Barbara Flunger. Dit onderzoek wordt door een Master student uitgevoerd. In dit onderzoek wordt onderzocht welke rol behoefte-ondersteuning van de leerkracht speelt voor de motivatie van de studenten. Leerkrachten kunnen bijdragen aan de motivatie van studenten voor de biologieles door de drie psychologische basisbehoeften (zich autonoom, competent en verbonden te voelen) te ondersteunen. Dit kunnen leerkrachten doen door studenten autonomie te bieden. In ons onderzoek wordt onderzocht hoe leerlingen behoefte-ondersteuning beoordelen en in hoeverre studenten gemotiveerd zijn voor de online en praktische biologielessen. Deze brief geeft je informatie over de inhoud van het onderzoek. Resultaten van dit onderzoek worden gepubliceerd.

Onderzoeksvragen

In dit onderzoek proberen we de volgende onderzoeksvragen te beantwoorden:

Vraag 1: In hoeverre bevordert de perceptie van de autonomieondersteuning door leraren de motivatie van middelbare scholieren in online en praktische biologielessen?

Vraag 2: Hoe verschilt de associatie tussen autonomieondersteuning en motivatie in online les versus praktijkles?

Hoe wordt het onderzoek uitgevoerd?

In maart 2021 wordt aan je gevraagd om een vragenlijst over de instructie van je leerkracht en jouw motivatie voor de biologieles in te vullen. De afname van de vragenlijst gebeurt online via een link. Je zal hier ongeveer 30 minuten mee bezig zijn.

Vertrouwelijkheid en vrijwilligheid

De gegevens van dit onderzoek zullen door de onderzoeker alleen worden gebruikt voor wetenschappelijke doeleinden. Deze gegevens kunnen worden gebruikt voor vervolg- of toekomstig onderzoek dat mogelijk een ander doel heeft. De studenten zullen gevraagd worden aanvullende persoonlijke gegevens te verstrekken, namelijk achtergrond, leeftijd, geslacht, en klas. Deze gegevens worden gebruikt om de rol van behoefte-ondersteuning op de motivatie van studenten van verschillende klassen te kunnen onderzoeken. Voor alle gegevens geldt dat deze in geen geval bekeken worden per student. Het gaat om de resultaten voor de hele groep tezamen. De anonimiteit van deelnemers blijft gewaarborgd. Alle ethisch verantwoorde keuzes behorende bij dit onderzoek zullen officieel worden goedgekeurd door de ethische commissie Universiteit Utrecht.

Je persoonsgegevens worden op een andere computer opgeslagen dan de onderzoeksgegevens zelf (de zogenaamde ruwe data). De computer waarop je persoonlijke gegevens zijn opgeslagen, is beveiligd volgens de hoogste normen en alleen de onderzoeker heeft toegang tot deze informatie. De gegevens zelf worden ook beschermd door een beveiligingscode. Je gegevens worden minimaal 10 jaar bewaard. Dit in overeenstemming met de richtlijnen van de VSNU Vereniging van Universiteiten in Nederland. Voor meer informatie over privacy verwijzen wij je naar de website van de Autoriteit Persoonsgegevens: https://autoriteitpersoonsgegevens.nl/nl/onderwerpen/avg-europese-privacywetgeving.

Wetenschappelijk onderzoek naar leren is zeer afhankelijk van vrijwillige deelname. Wij zullen daarom enorm gebaat zijn bij je deelname. Als je toch bezwaar heeft tegen deelname aan het onderzoek, kan je contact opnemen met mij (zie contactgegevens onderaan) of met de leerkracht. Je zal dan niet deelnemen aan het onderzoek en er zullen geen gegevens worden verzameld. Deelname kan te allen tijde zonder opgave van redenen en zonder gevolgen voor de deelnemer worden beëindigd. Als je je toestemming intrekt, kunnen de gegevens die tot dan toe zijn verzameld worden gebruikt. Je gegevens blijven vertrouwelijk en ze worden (waar mogelijk) geanonimiseerd voordat ze worden opgeslagen. Verder, hebben alleen de betrokken onderzoekers toegang tot die gegevens.

Ik hoop je hierbij voldoende geïnformeerd te hebben. Mocht je nog vragen of opmerkingen hebben over het onderzoek, dan kan je contact opnemen met Nancy Younes, email: n.younes@students.uu.nl, of met projectleider Barbara Flunger, e-mail: b.flunger@uu.nl. Indien je klachten hebt over het onderzoek, kan je dit bespreken met de contactpersoon, Dr. Barbara Flunger. Wil je dit liever niet, dan kan je je wenden tot de klachtenfunctionaris, bereikbaar via: klachtenfunctionaris-fetcsocwet@uu.nl.

Met vriendelijke groet,

Nancy Younes

Masterstudent Onderwijswetenschappen

Universiteit Utrecht

Toestemmingsverklaring

Utrecht, Maart 2021

Hierbij verklaar ik de bovenstaande informatie zorgvuldig te hebben doorgelezen. Ik heb voldoende tijd gekregen om te beslissen of ik zal deelnemen aan dit onderzoek. Ik weet dat deelname aan dit onderzoek op vrijwillige basis is en dat de gegevens anoniem zullen worden verwerkt. Gedurende het gehele onderzoek kan ik afzien van mijn deelname, dit heeft op geen enkele wijze nadelige gevolgen voor mij. Ik ga akkoord met deelname aan het onderzoek volgens de bovenstaande procedure en geef toestemming voor het gebruik van de daarmee verkregen gegevens.

Datum: __/__/__

………………………………..

(handtekening)

Onderzoeker: hierbij verklaar ik deze proefpersoon volledig te hebben geïnformeerd omtrent het onderzoek.

Datum: __/__/__

……………………………….. ………………………………..

(naam onderzoeker) (handtekening onderzoeker)

Appendix B

Planning

	Commitments
Week 1 11 Nov. 2020	Search literature and get familiarized with the topic. Think of possible research questions. Contact biology teacher to discuss the possibilities.
Week 2 18 Nov. 2020	Adapt research questions, start writing problem statement and synthesizing literature.
Week 3 25 Nov. 2020	Write the introduction and think of possible study design. Re-write the research questions accordingly.
Week 4 2 Dec. 2020	Start writing the method section and find proper literature for substantiation.
Week 5 & 6 9 - 16 Dec. 2020	Think of data analyses. Read related chapters in Field, 2018 on multiple regression, ANOVA, MANOVA.. (Youtube tutorials too) Finalize the draft thesis plan and prepare the handout for a round table meeting with the supervisor and the peers.
Week 7 13 Jan. 2021	Submit draft research plan and get familiarized with UU-ser website. Read more about the topics and determine the final research questions and appropriate data analyses for them.
Week 8 20 Jan. 2021	Consider peer and supervisor feedback and work on improving the research plan.
Week 9 27 Jan. 2021	Revise the final version of the research plan and get the APA and language checks. Reconsider the content and amend parts of the text to improve the whole paper.
Week 10 7 Feb. 2021	Submit the research plan.
Week 11 & 12 10 - 20 Feb. 2021	Work further on the instruments, conduct EFA to check validity and reliability of the instrument.
Week 13 24 Feb. 2021	Schedule peer feedback and prepare for the roundtable session.
Week 14 10 Mar. 2021	Roundtable session and presentation of the study.
Week 15 24 Mar. 2021	Data collection takes place around this time.

Week 16 7 Apr. 2021	
Week 17 14 Apr. 2021	Data analysis and work on the results.
Week 18 21 Apr. 2021	
Week 19 28 Apr. 2021	Work on the discussion section.
Week 20 5 May 2021	
Week 21 12 May 2021	Manage for peer feedback.
Week 22 17 May 2021	Work on the draft version of the thesis and submit it.
24 May – 6 June 2021	Revise the whole paper, get feedback from a peer, and finalize the whole study. Then prepare for the master thesis conference.
16 June 2021	Present the study during the Master thesis conference.

Appendix C

Academic Integrity

Participants were informed that they would participate in a master thesis study about perceived autonomy support and student motivation to learn biology in hybrid learning environment. In addition to the baseline variables (i.e. perceived autonomy support and the three types of motivation), several demographics and control variables were included, such as: gender, age, background and psychological needs according to SDT.

Limesurvey was used to create an online questionnaire which took approximately 30 minutes to complete. The questionnaire was in Dutch. Participants aged 17 and above, so that no informed consent is needed from parents according to the Dutch rules and regulations of the Central Committee on Research Involving Human Subjects.

Right before data collection, participants got access to the informed consent on the aim of the study, confidentiality and the right to withdraw (Appendix A). When participants consented, they were asked to provide demographic information (i.e. their gender, age, background, language they speak at home, class and place of birth). Then, participants answered questions on their autonomy, competence, and relatedness to the biology instructors in the online lesson and practicums. They also answered questions on their intrinsic, extrinsic, and amotivation, as well as their perceptions on biology instructors' autonomy-supportive practice both in the online lesson and practicums.

All participants' information was made anonymous by giving them a random code. Their personal data will be stored on a different computer away from the data used for the study purposes. The computer where personal data are stored will be well- secured, and only the researcher and the supervisors will have access to these data. This goes in accordance with the guidelines provided by the VSNU Association of Universities in the Netherlands.

Participation in this study was completely voluntary. Participants were able to end their participation at any time, without any explanation and without any negative consequences. Then the data collected up to the point of ending one's participation would be used in the analyses, unless participants explicitly informed us otherwise. Then it was possible to remove their data.

Appendix D

Student Motivation and Teacher Autonomy Support Questionnaire

VRAGENLIJST OVER JE MOTIVATIE

VRAGENLIJST OVER JE MOTIVATIE TIJDENS DE ONLINE EN PRAKTISCHE BIOLOGIELES

Beste student,

Met behulp van deze vragenlijst willen we graag weten wat jij van de online en de praktische biologieles vindt. De deelname aan het onderzoek is anoniem en vrijwillig. Dit betekent dat je biologie leraar niet te weten krijgen wat je ingevuld hebt en dat je niet mee hoeft te doen als je dat echt niet wilt. Het invullen van de vragenlijst duurt 30 minuten.
Let op de volgende punten:

- De vragen gaan allemaal over de online en praktische biologieles.
- Vul de vragenlijst alleen in.

Bij iedere stelling mag je invullen hoe goed deze vraag past bij jou. Het gaat erom wat jij vindt. Je hebt 4 antwoordmogelijkheden. Geef aan of de stelling helemaal niet waar is voor jou, eerder niet waar, gedeeltelijk waar of helemaal waar.

Voorbeeld:

	Helemaal niet waar	Eerder niet waar	Gedeeltelijk waar	Helemaal waar
Ik vind honden leuk.	☐	☒	☐	☐

- Kruis per vraag slechts één mogelijkheid aan.
- Probeer alle vragen te beantwoorden. Als je een vraag niet zinvol kunt beantwoorden, sla de vraag over.
- Er zijn geen goede of foute antwoorden. Geef bij iedere vraag je persoonlijke mening aan.

Veel plezier met het invullen!

CONTACT
Dr. Barbara Flunger, Universiteit Utrecht; Heidelberglaan 1, 3584 CS Utrecht; Tel.: +31 30 253 3707; E-Mail: b.flunger@uu.nl;

Over jou

In het eerste deel van deze vragenlijst hebben we enkele vragen over jou.

Hoe oud ben je?

____

Ben je een meisje of een jongen?

____

In welke Klas zit je?

____

In welk land ben je geboren?

____

Spreken jullie thuis meestal Nederlands?

☐ **ja**

Nee, welke taal spreken jullie het meest? ___________________________________

Ik zie mezelf als iemand die…	Helemaal niet waar	Eerder niet waar	Gedeeltelijk waar	Helemaal waar
… hard werkt.	☐	☐	☐	☐
… slordig is.	☐	☐	☐	☐
… zorgvuldig is.	☐	☐	☐	☐

Op dit moment leer je biologie via online lessen en praktijksessies op school. We zouden graag willen weten hoe interessant je deze lessen vindt.	Helemaal niet waar	Eerder niet waar	Gedeeltelijk waar	Helemaal waar
Zou je graag meer biologielessen hebben?	☐	☐	☐	☐
Hoe zeer kijk je uit naar de online biologielessen?	☐	☐	☐	☐
Hoe zeer kijk je uit naar de biologiepraktijklessen?	☐	☐	☐	☐
Zou je zelfs een deel van je vrije tijd opgeven om iets nieuws over biologie te leren?	☐	☐	☐	☐
Als je bezig met biologie bent, gebeurt het soms dat je niet merkt dat de tijd voorbij gaat?	☐	☐	☐	☐

De Online Biologieles (voor jou)

In het volgende deel willen we weten hoe jij de online biologieles ervaart. Geef aan in hoeverre de stellingen bij jou passen.

Tijdens de online biologieles en bij mijn Biologie leraar…				
	Helemaal niet waar	Eerder niet waar	Gedeeltelijk waar	Helemaal waar
… voel ik mij geaccepteerd.	☐	☐	☐	☐
… voel ik me genegeerd.	☐	☐	☐	☐
… voel ik me onbelangrijk.	☐	☐	☐	☐
… krijg ik het gevoel dat hij/zij om mij geeft.	☐	☐	☐	☐

Tijdens de online biologieles heb ik over het algemeen het gevoel dat …				
	Helemaal niet waar	Eerder niet waar	Gedeeltelijk waar	Helemaal waar
… ik ook de moeilijke online opdrachten kan oplossen.	☐	☐	☐	☐
… het mij lukt om de online opdrachten goed te maken.	☐	☐	☐	☐
… ik de moeilijke online opdrachten ook goed begrijp.	☐	☐	☐	☐
… ik de online opdrachten op mijn eigen manier kan doen.	☐	☐	☐	☐
… ik zelf kan bepalen hoe ik aan een online opdracht werk.	☐	☐	☐	☐
… ik op mijn eigen manier aan nieuwe online opdrachten kan werken	☐	☐	☐	☐

De vragen in het volgende deel gaan over de ondersteuning door je leraar in de online biologieles. Hoeveel keuzes en uitleg krijg je tijdens de online biologieles?

Tijdens de online biologieles …				
	Helemaal niet waar	Eerder niet waar	Gedeeltelijk waar	Helemaal waar
… krijg ik veel keuzes, opties en kansen van mijn leraar.	☐	☐	☐	☐
… heb ik maar weinig te zeggen over de dingen die in onze online sessie gedaan worden.	☐	☐	☐	☐
… mag ik vaak op mijn eigen manier op de online materialen werken.	☐	☐	☐	☐
… legt de leraar mij uit hoe belangrijk de informatie van de online biologieles is in mijn dagelijks leven.	☐	☐	☐	☐
… legt de leraar mij vaak uit dat ik de informatie van de online biologieles nog nodig heb in mijn	☐	☐	☐	☐

toekomst.				
… moedigt de leraar mij aan na te denken over hoe de informatie van de online biologieles in het echt gebruikt kan worden.	☐	☐	☐	☐
… laat de leraar mij zien dat de online biologieles interessant is.	☐	☐	☐	☐
… zoekt de leraar nieuwe manieren om de online biologieles interessanter te maken voor mij.	☐	☐	☐	☐
… zorgt mijn leraar ervoor dat ik de online biologie boeiend vind.	☐	☐	☐	☐
Als ik tijdens de online biologieles verdrietig, zenuwachtig, verveeld of boos ben,				
… vraagt mijn leraar of ik er over wil praten.	☐	☐	☐	☐
… luistert mijn leraar goed naar wat ik zeg.	☐	☐	☐	☐
… heeft mijn leraar hier begrip voor.	☐	☐	☐	☐

Leren

In het volgende deel willen we meer weten over hoe je tijdens de **online** biologieles leert en wat je over de **online** biologieles denkt.

Er kunnen lessen zijn waarin je niet gemotiveerd bent. In het volgende willen we weten hoe vaak en waarom dit in de online biologieles gebeurt.

	Helemaal niet waar	Eerder niet waar	Gedeeltelijk waar	Helemaal waar
Ik vind de online biologieles niet interessant.	☐	☐	☐	☐
Ik houd niet van de opdrachten bij de online biologieles.	☐	☐	☐	☐
Ik zie geen reden om biologie online te leren.	☐	☐	☐	☐
Meedoen met de online biologieles is niet belangrijk voor mij.	☐	☐	☐	☐

Waarom doe je je best voor de online biologieles? Omdat ..

	Helemaal niet waar	Eerder niet waar	Gedeeltelijk waar	Helemaal waar
… de online biologieles leuk is.	☐	☐	☐	☐
… ik graag oefeningen maak in de online biologieles.	☐	☐	☐	☐
… ik graag biologie vragen in de online les beantwoord.	☐	☐	☐	☐
… ik me graag met de online biologieles bezighoud.	☐	☐	☐	☐
… ik in de problemen kom als ik het in de online les niet maak.	☐	☐	☐	☐
… ik dit in de online les moet doen.	☐	☐	☐	☐
… ik anders problemen met de leraar tijdens de online les krijg.	☐	☐	☐	☐
… dat de regel in de online les is, omdat het zo hoort.	☐	☐	☐	☐

De Biologiepraktijkles (voor jou)

In biologie heb je naast online lessen ook praktijklessen. In het volgende deel gaan de vragen daarom over de biologiepraktijkles. We willen weten hoe je de biologiepraktijkles ervaart.

Tijdens de biologiepraktijkles en bij mijn Biologie leraar…	Helemaal niet waar	Eerder niet waar	Gedeeltelijk waar	Helemaal waar
… voel ik mij geaccepteerd.	☐	☐	☐	☐
… voel ik me genegeerd.	☐	☐	☐	☐
… voel ik me onbelangrijk.	☐	☐	☐	☐
… krijg ik het gevoel dat hij/zij om mij geeft.	☐	☐	☐	☐

Tijdens de praktische biologieles heb ik over het algemeen het gevoel dat …	Helemaal niet waar	Eerder niet waar	Gedeeltelijk waar	Helemaal waar
… ik ook de moeilijke praktische opdrachten kan oplossen.	☐	☐	☐	☐
… het mij lukt om de praktische opdrachten goed te maken.	☐	☐	☐	☐
… ik de moeilijke praktische opdrachten ook goed begrijp.	☐	☐	☐	☐
… ik de praktische opdrachten op mijn eigen manier kan doen.	☐	☐	☐	☐
… ik zelf kan bepalen hoe ik aan een praktische opdracht werk.	☐	☐	☐	☐
… ik op mijn eigen manier aan nieuwe praktische opdrachten kan werken	☐	☐	☐	☐

De vragen in het volgende deel gaan over de ondersteuning door je leraar in de biologiepraktijkles. Hoeveel keuzes en uitleg krijg je tijdens de praktijkles?

Tijdens de praktische biologieles …	Helemaal niet waar	Eerder niet waar	Gedeeltelijk waar	Helemaal waar
… krijg ik veel keuzes, opties en kansen van mijn leraar.	☐	☐	☐	☐
… heb ik maar weinig te zeggen over de dingen die in onze praktijkles gedaan worden.	☐	☐	☐	☐
… mag ik vaak op mijn eigen manier in de practicum werken.	☐	☐	☐	☐
… legt de leraar mij uit hoe belangrijk praktische biologie is in mijn dagelijks leven.	☐	☐	☐	☐
… legt de leraar mij vaak uit dat ik praktische biologie nog nodig heb in mijn toekomst.	☐	☐	☐	☐
… moedigt de leraar mij aan na te denken over hoe praktische biologie in het echt gebruikt kan worden.	☐	☐	☐	☐

… laat de leraar mij zien dat praktische biologie interessant is.	☐	☐	☐	☐
… zoekt de leraar nieuwe manieren om de praktische biologieles interessanter te maken voor mij.	☐	☐	☐	☐
… zorgt mijn leraar ervoor dat ik praktische biologie boeiend vind.	☐	☐	☐	☐
Als ik verdrietig, zenuwachtig, verveeld of boos tijdens de praktische biologieles ben,				
… vraagt mijn leraar of ik er over wil praten.	☐	☐	☐	☐
… luistert mijn leraar goed naar wat ik zeg.	☐	☐	☐	☐
… heeft mijn leraar hier begrip voor.	☐	☐	☐	☐

Leren

In het volgende deel willen we meer weten over hoe je tijdens biologie leert en wat je over de **biologiepraktijkles op school** denkt.

Er kunnen lessen zijn waarin je niet gemotiveerd bent. In het volgende willen we weten hoe vaak en waarom dit in de biologiepraktijkles gebeurt.

	Helemaal niet waar	Eerder niet waar	Gedeeltelijk waar	Helemaal waar
Ik vind de praktische biologieles niet interessant.	☐	☐	☐	☐
Ik houd niet van de opdrachten bij de praktische biologieles.	☐	☐	☐	☐
Ik zie geen reden om in de praktische biologieles te leren.	☐	☐	☐	☐
meedoen met de praktische biologieles is niet belangrijk voor mij.	☐	☐	☐	☐

Waarom doe je je best voor de biologiepraktijkles? Omdat ..

	Helemaal niet waar	Eerder niet waar	Gedeeltelijk waar	Helemaal waar
… de praktische biologieles leuk is.	☐	☐	☐	☐
… ik graag oefeningen maak met de praktische biologieles .	☐	☐	☐	☐
… ik graag praktische biologie vragen beantwoord.	☐	☐	☐	☐
… ik me graag met de praktische biologieles bezighoud.	☐	☐	☐	☐
… ik in de problemen kom als ik het bij de praktijkles niet maak.	☐	☐	☐	☐
… ik dit moet doen bij de praktijkles.	☐	☐	☐	☐
… ik anders problemen met de praktijkles leraar krijg.	☐	☐	☐	☐
… dat de regel bij de praktijkles is, omdat het zo hoort.	☐	☐	☐	☐

Bedankt voor het invullen!

Appendix E

Tables of EFA Results, Reliability Tests, and Structure Figure

Table 1

Factor loadings for Exploratory Factor Analysis with Oblimin Rotation of Psychological Needs

Item	Communalities	Competence	Autonomy	Relatedness
OLCom1	.56	-.90		
OLCom2	.75	-.68	.31	
OLCom3	.70	-.77		
OLAut1	.54		.88	
OLAut2	.77		.96	
OLAut3	.77		.94	
OLREL1	.66			.75
OLREL2r	.85			.89
OLREL3r	.88			.78
OLREL4	.90			.67
PrCom1	.76	.37	.70	
PrCom2	.76	.70	.37	
PrCom3	.73	.66	.38	
PrAut1	.76	.83		
PrAut2	.73	.84		
PrAut3	.81	.90		
PrREL1	.76			.79
PrREL2r	.80		.86	
PrREL3r	.75		.74	
PrREL4	.61			.61
Eigenvalues online		1.2	3.9	2.2
Percentages of variance online		12.9%	39.1%	21.9%
Eigenvalues FTF		1.7	4.8	1.02
Percentages of variance FTF		16.7%	47.8%	10.15%

Table 2

Item Analysis for Reliability Testing – Control Variables

	Cronbach's alpha	Item-rest correlation	Alpha if item deleted
Control Variable Relatedness OL	1.00		
OLREL2r		1.00	
OLREL3r		1.00	
Control Variable Relatedness FTF	1.00		
PrREL2r		1.00	
PrREL3r		1.00	
Control Variable Competence OL	.80		
OLCom1		.65	.73
OLCom2		.69	.68
OLCom3		.61	.77
Control Variable Competence FTF	.84		
PrCom1		.64	.85
PrCom2		.75	.74
PrCom3		.74	.75
Control Variable Autonomy OL	.93		
OLAut1		.83	.92
OLAut2		.85	.90
OLAut3		.89	.87
Control Variable Autonomy FTF	.88		
FTFAut1		.74	.86
FTFAut2		.78	.83
FTFAut3		.80	.81

Table 3

Results of the Second Exploratory Factor Analysis with Oblimin Rotation of Intrinsic, Extrinsic, and Amotivation in OL and FTF Biology

Item	Communalities	Extrinsic Motivation	Intrinsic Motivation	Amotivation
OLMoEx1	.62	.77		
OLMoEx2	.67	.81		
OLMoEx3	.54	.72		
OLMoEx4	.72	.86		
OLMoIt1	.63		.61	
OLMoIt2	.67		.71	
OLMoIt3	.72		.91	

OLMoIt4	.72		.67	
OLMoA1r	.56			-.61
OLMoA3r	.72			-.83
OLMoA4r	.81			-.94
PrMoEx1	.68	.82		
PrMoEx2	.71	.78		
PrMoEx3	.71	.83		
PrMoEx4	.66	.81		
PrMoIt1	.87		.87	
PrMoIt2	.80		.88	
PrMoIt3	.76		.93	
PrMoIt4	.86		.84	
PrMoA3r	.92			.94
PrMoA4r	.91			.96
Eigenvalues online		2.5	3.7	1.2
Percentages of variance online		23.1%	33.6%	10.5%
Eigenvalues FTF		2.5	4.17	1.17
Percentages of variance FTF		25.5%	41.6%	11.6%

Table 4

Results of the Exploratory Factor Analysis with Oblimin Rotation of the Three Components of Perceived Autonomy Support in OL Biology

Items	Communalities	Provision of choices	Relevance	Openness to communication
OLAuSc1	.43			.50
OLAuSc2r	.69	.84		
OLAuSc3	.65			.80
OLAuSR1	.57		.69	
OLAuSR2	.57		.81	
OLAuSR3	.67		.76	
OLAuSN1	.62	**.47**	**.56**	
OLAuSN2	.57		.70	
OLAuSN3	.61		.67	
OLAuSA1	.59	**.59**		**.32**
OLAuSA2	.79			.70
OLAuSA3	.73			.81

Eigenvalues online	1.12	4.75	1.6
Percentages of variance online	9.39%	39.5%	13.3%

Note. Factor loadings of items that loaded on two factors are in boldface.

Table 5

Item Analysis for Reliability Testing – Perceived Autonomy Support in OL and FTF Biology

Items	Cronbach's alpha	Item-rest correlation	Alpha if item deleted
Factor OL Relevance	.84		
OLAuSR1		.61	.82
OLAuSR2		.55	.83
OLAuSR3		.68	.81
OLAuSN1		.59	.82
OLAuSN2		.64	.82
OLAuSN3		.66	.81
OLAuSc1		.46	.84
Factor OL Accepting Expressions of Negativity	.82		
OLAuSA1		.51	.89
OLAuSA2		.83	.56
OLAuSA3		.68	.73
Factor FTF Relevance	.89		
PrAuSR1		.72	.87
PrAuSR2		.66	.88
PrAuSR3		.67	.87
PrAuSN1		.77	.86
PrAuSN2		.68	.87
PrAuSN3		.69	.87
PrAuSc1		.60	.88
Factor FTF Accepting Expressions of Negativity	.85		
PrAuSA1		.63	.91

PrAuSA2	.82	.71
PrAuSA3	.77	.79

Figure 1

New Structure of Student Psychological Needs in OL and FTF Biology