Sustainability of Developed Self-Regulation by Means of Formative Assessment Among Young Adolescents: A Longitudinal Study

Kelly Beekman[1,2]*, Desirée Joosten-Ten Brinke[2] and Els Boshuizen[2]

[1]Research group Technology Enhanced Assessment, Fontys University of Applied Sciences, Tilburg, Netherlands, [2]Faculty of Educational Sciences, Open Universiteit of the Netherlands, Heerlen, Netherlands

The present study examined the long-term impact of a formative assessment intervention in primary education on the development of students' levels of self-regulation, motivation, and self-efficacy after their transition to secondary education. Participants in the study included 695 Dutch sixth graders from 17 schools. A longitudinal design with measurements on three time points was adopted. The first part of the study, consisting of a pretest, the intervention, and posttest, was conducted during the students' last 7 months in primary education using two experimental conditions, with peer- and self-assessment, and a control condition. A follow-up took place 10 weeks later, after the summer break and at the commencement of the participants' secondary education. Longitudinal multilevel analyses showed that the development of self-regulation and motivation is significantly positively associated with the formative self- and peer-assessment interventions and continues after the transition to secondary education. Results are discussed with regard to theoretical and practical consequences.

Keywords: self-regulation, formative assessment, self-regulated learning, peer-assessment, self-assessment, feedback, motivation

INTRODUCTION

Research has identified the significant role of self-regulation in promoting achievement across various school levels, from primary to higher education (Clark, 2012; McMillan et al., 2017; Allal, 2020). Research shows that students who have been trained in self-regulation attain higher levels of motivation and achievement, mainly because self-regulated learners acquire the adaptive and learning characteristics required for engagement with the learning process and subsequent successful performance (Clark, 2012; Allal, 2020; Greene, 2020; Moet zijn Nicol and Macfarlane-Dick, 2006). According to Dignath et al. (2008) developing self-regulation in early academic years is emphasized, as it is a key ability necessary for the development of a successful learner in the succeeding levels of education. It seems to be fruitful to start developing self-regulation in primary education to empower students by increasing their repertoire of learning strategies and support them to apply these strategies in a self-regulated manner (Cleary and Zimmerman, 2004; Meusen-Beekman et al., 2015). Formative assessments can be implemented as an instruction, during which practices are guided, and learning processes are improved through developing self-regulated learning strategies among learners (Andrade and Cizek, 2010; Clark, 2012; McMillan et al., 2017; Allal, 2020; Greene, 2020). The question is whether learned skills in primary education endure after the

transition to secondary education. Do secondary school students still benefit from self-regulation skills learned in primary education? Longitudinal studies investigating how students develop self-regulation skills seem to be scarce. Therefore, the major aim in this longitudinal study is to examine the impact of formative assessment on the development of self-regulation, motivation and self-efficacy among sixth graders, and whether the effects sustain after the transition to secondary education. Part of this analysis will include descriptions of the school-to-school transition, principles of self-regulation, and formative assessments, their longitudinal effects, and their underlying mechanisms.

Theoretical and Empirical Background

Learning is an active, constructive process. According to Pintrich (2003), regulating learning signifies a dynamic response to the demands of a learning task. Regulating learning can be defined as learners' proactive behaviors toward attaining learning goals (Zimmerman, 2002). Self-regulation is a complex, cyclical process that refers to receiving and using feedback from previous task performances to evaluate and adjust one's learning process, with an optimization of academic performance and development as a result (Zimmerman, 2002; De Boer et al., 2013; Allal, 2020; Greene, 2020). Students who can self-regulate cognitive, motivational, and behavioral aspects are more effective learners (Zimmerman, 2002; Greene, 2020). This fact applies to students at all levels of education, although there are differences in the effectiveness of different learning strategies at various stages. Self-regulation development can be stimulated during early academic years (Dignath et al., 2008). To improve self-regulation strategies and strategic behaviors, students need to frequently utilize and adapt strategies, such as planning, monitoring, and reflecting, and gain experience using them. External regulation, however, refers to the students' dependence on the teacher or other external sources to regulate and control their learning processes. The more students are able to self-regulate their learning, the less dependent they become on external sources (McMillan et al., 2017).

Knowledge of self-regulation strategies does not necessarily mean students will be skilled or motivated to use them efficiently (Cleary and Chen, 2009; Xiao and Yang, 2019). Students have to be motivated to be interested in, able to initiate, and remain engaged in tasks, particularly as students encounter challenging learning materials (Schunk and Ertmer, 2000). Research shows that motivation generally diminishes over the course of schooling (Groves, 2005; Martens, et al., 2010). In view of this concern, there has been a strong interest in studying motivation in relation to learning and particularly in motivational aspects of self-regulated learning (Pintrich, 2003; Martens et al., 2004; Greene, 2020). Ryan and Deci (2000) differ intrinsic motivation and extrinsic motivation. Extrinsic motivation refers to performances or activities to attain a tangible reward. When students are more extrinsically motivated and, thus, more concerned with obtaining some reward, that behavior can hinder intrinsic motivation. Intrinsic motivation concerns activities that are carried out for the satisfaction of the activity itself. Intrinsically motivated students are more interested and curious. They are more explorative, and tend to exchange information more often with their peers than extrinsically motivated students (Martens et al., 2004; Vansteenkiste et al., 2004). Ryan and Deci (2000) pointed out that students who are highly intrinsically motivated outperform their less intrinsically motivated peers. Extrinsic goals do not have that positive effect (Vansteenkiste et al., 2004). Being intrinsically motivated should lead to higher levels of engagement in the task and has positive effects on self-regulation of learning (De Boer et al., 2013).

Not only motivation, but also self-efficacy is very important to the development of self-regulation. Self-efficacy refers to ones' beliefs in personal capabilities with regard to organizing and executing courses of action (Bandura, 1997). According to Schunk and Usher (2011) these beliefs directly affect self-regulation and motivation, which, in turn, affects student task interest and task persistence, and usage of self-regulation skills.

A strategy to improve self-regulation among students is formative assessment. According to Greene (2020) formative assessment drives self-regulation strategy acquisition among learners and has been directly related to self-regulation by a growing body of research (Nicol and Macfarlane-Dick, 2006; Black and Wiliam, 2009; Clark, 2012; Greene, 2020). Clark describes formative assessment as (2012, pp. 217) "a process with the potential to support learning beyond school years by developing learning strategies which individuals may rely on across their entire life-span." Formative assessment is designed to support teaching and learning by emphasizing skills such as planning, monitoring, and reflecting while guiding further learning and improving performance outcomes. Thus, formative assessment encapsulates self-regulated learning (Clark, 2012; McMillan et al., 2017; Greene, 2020).

Formative assessment consists of five key strategies: peer- and self-assessment, rich questioning, feedback, and the assessment dialogue between learners and teachers in relation to clarifying, sharing, and understanding learning intentions and success criteria (Black and Wiliam, 1998). Both self- and peer-assessments can be well integrated into whole-classroom formats and are student-centered assessment forms (Sluijsmans et al., 2013; McMillan et al., 2017).

Meusen-Beekman et al. (2015) provided evidence, that peer and self-assessment are effective interventions to develop self-regulation in primary education. Students' self-regulation skills increased under the influence of formative assessments. Self- and peer-assessments appeared to be equally effective in developing self-regulation among sixth graders. With regard to intrinsic motivation, the assessment led students to gain a personal interest in a subject and feel motivated to develop competence. These results converge with findings from other studies on increasing motivation by means of self-regulation (Cleary and Zimmerman, 2004; McMillan et al., 2017; Yan et al., 2020).

Developing a self-regulation strategy repertoire by means of formative assessment seems to be effective in primary education, at least within the time scope of several studies, but can it prevent an achievement gap on learning strategies throughout secondary education? Research has shown that self-regulated learning often decreases in the first years of

secondary education (Peetsma et al., 2005; Van der Veen and Peetsma, 2009). In secondary schools, teachers expect students to engage in independent study, complete a greater amount of homework assignments, and manage uncoordinated assignments from different teachers. Students need to have a repertoire of self-regulation strategies to meet these expectations (Cleary and Zimmerman, 2004). However, students often show deficits in self-regulation because of their poor mastery of effective learning strategies. They lack the skills needed to select and apply strategies, which results in setting inappropriate goals, lacking planning skills and failing to properly monitor learning activities (Boekaerts et al., 2000; Cleary, 2004), This leads to some students struggling in secondary school.

Several studies have shown a decrease in learning motivation over the years, which starts during primary school (Harter, 1981; Bouffard et al., 2003). Although there is evidence of a decrease in learning motivation, underlying factors are not well understood. According to Spinath and Spinath (2005), the general decrease in learning motivation is paralleled by a decrease in competence beliefs (i.e. self-efficacy) and a lack of sufficient learning strategies.

In addition, research has shown that summer vacation affects previously established achievements. Cooper et al. (1996) found differences in the effect of summer vacation on different skill areas. Alexander et al. (2007) expressed that summer losses are generally greater in domains involving memorization than conceptual understanding and problem solving. A comparison of achievement-gains over the school year and the summer months, showed that the majority of achievement loss commenced during the summer, when children were not in school.

Deficits in self-regulation, but also contextual and developmental changes at early adolescence, increase the risk that students may not reach their potential (Hill and Tyson, 2009). These findings support the need for early and sustained interventions on developing self-regulation to prevent the achievement gap from opening wide and the differential learning loss experienced in the summer-months.

Considering the significance of self-regulation for student ability to learn and for academic outcomes, it is important to gain an understanding of the longitudinal development of self-regulation. Results from several studies show substantial differences in both self-regulation and motivational variables over the course of school years (Cleary, 2004; Peetsma et al., 2005; Van der Veen and Peetsma, 2009). However, no studies on long-term effects of formative assessment on self-regulation and variables, such as motivation and self-efficacy, were found. Nor were studies found concerning the development of self-regulation during school-to-school transitions between primary and secondary education. Whether or not developing self-regulation through the primary school curriculum by means of formative assessments helps students to adapt, utilize, and adjust self-regulation strategies and enhances their motivation and academic achievements in following school levels is investigated in the present study.

The Present Study

There is clear evidence that the frequency and quality of students' self-regulation strategy use is predictive of academic achievement. Meusen-Beekman et al. (2016) showed that formative assessment is effective to develop self-regulation by sixth-grade students. In the present study, a longitudinal design was adopted to study the impact of formative assessment on self-regulation and its association with intrinsic motivation and self-efficacy in primary and secondary education. The focus of this study is on whether self-regulation skills learned by students in upper primary education by means of formative assessments will last after the transition to secondary education. The formative assessment intervention includes peer-assessment or self-assessment. Black and Wiliam's key strategies for formative assessment (2003), peer-assessment, self-assessment, rich questioning, criteria for success, and feedback were embedded in both interventions.

Research Questions and Hypotheses

Results from several studies (Cleary, 2004; Peetsma et al., 2005; Van der Veen and Peetsma, 2009) provided evidence that substantial differences in self-regulation, motivation, and self-efficacy could be expected during the course of secondary school years. In this experimental study the sustainability of self-regulation skills and intrinsic motivation, developed by means of formative assessments in primary education, will be explored after the transition to secondary education. Simultaneously, the determinants of self-efficacy, extrinsic motivation, and external regulation among students are examined. In sum, the following research questions were specified:

1) What are the effects of the formative assessment intervention on self-regulation and external regulation after the transition to secondary education? In line with literature outcomes, it was expected that the accomplished effects of the formative assessment intervention on self-regulation among sixth graders would significantly decrease after the transition to secondary school, despite the training of self-regulation skills in primary education. Also, the effects of the assessment intervention on external regulation were explored. Research showed that students who are able to self-regulate learning, are less depended on external sources (Cleary, 2004). Because we expected a decrease in self-regulation at the start of secondary education, we did not expect changes in students' dependence on external sources.
2) What are the effects of the formative assessment intervention on intrinsic and extrinsic motivation after the transition to secondary education? Based on literature a decrease was expected in intrinsic and extrinsic motivation after the transition to secondary school (Spinath and Spinath, 2005).
3) What are the effects of the peer- and self-assessment interventions on self-efficacy after the transition to secondary education? Spinath and Spinath (2005) suggest that a general lack of sufficient learning strategies, is paralleled by a decrease in competence beliefs. Therefore, we expected no differences on self-efficacy in both formative assessment intervention conditions.

TABLE 1 | Description of the sample for the pretest and posttest by condition.

Intervention	Peer-assessment	Self-assessment	Control	All
Primary Schools	5	4	8	17
Number of students (n)	231	185	279	695
Number of teachers	11	7	13	31
Student characteristics				
Female (n/%)	115 (49.8)	101 (54.6)	139 (49.8)	355 (51.1)
Male (n/%)	116 (50.2)	84 (45.4)	140 (50.2)	340 (48.9)
Teacher characteristics				
Female	8	3	8	19
Male	3	4	5	12
Mean age	39	40	41	39.6
Average years of teaching experience	15 years	14 years	16 years	15 years
School characteristics				
Average of Cito (max 550, min 500) (SD)	538.21 (8.94)	534.63 (9.72)	534.93 (8.69)	536.01 (9.15)
Average of reading comprehension (max 5) (SD)	3.65 (1.32)	3.49 (1.27)	3.56 (1.24)	3.56 (1.23)

Note. Cito = Standardized national exit-level test.

METHODS

Participants

The participants were part of an ongoing longitudinal study designed to investigate the long-term impact of formative assessment interventions on self-regulation, motivation, and self-efficacy. The sample consisted of 31 sixth-grade classes ($N = 695$ students) from 17 primary schools in a medium-sized Dutch city, randomly assigned from various schools. In every school, one of three treatment conditions, was implemented. Schools were first randomly assigned to either the intervention condition or the control condition (intervention assessment: $n = 9$; control condition: $n = 8$). To examine the differences between formative assessment forms, the intervention condition was split into either self-assessment or peer-assessment. To prevent the effect of teachers discussing their assessment forms, conditions were randomly assigned to schools. Thus, four schools (11 classes) were assigned to the peer-assessment condition, four schools (seven classes) were assigned to the self-assessment condition, and 13 classes were assigned to the control condition. Schools did not differ in pretest measures of reading level, average standardized test-scores (Cito), self-regulation, motivation, and self-efficacy. Characteristics of the participating students and their teachers (31) are listed in **Table 1**. Regarding the demographic characteristics listed in **Table 1**, no significant differences between conditions were found.

Procedure

This study included three measurements. Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The participants provided their informed consent to participate in this study. Data were collected in a pretest-posttest-follow-up experimental intervention design within three conditions: a self-assessment condition, a peer-assessment condition and a control condition. The data collection took place in three periods of 2 weeks, in which students were instructed to complete a questionnaire. The first measurement took place before the start of the intervention in January. The other two measurements took place within intervals of 20 weeks (June) and 10 weeks (September), respectively. The measurement in September was after an 8-week summer break (**Table 2** for a timeline of the procedure).

Intervention

Prior to the intervention, the pretest questionnaires were completed. During the following period, participants received several formative assessment assignments in the domain of writing. Participants in the self-assessment condition established criteria for the writing assignments, discussed requirements, standards, strengths, and weaknesses, and generated a list of qualities of an effective essay. They received checklists and rubrics and used them to self-assess their drafts in the self-assessment condition, after which they were given opportunities for revisions, feedback from their teacher, and evaluations. In the peer-assessment condition, participants followed the same procedures as compared to participants in the self-assessment condition. Only in this condition peer-assessment was implemented on the writing assignments, after which the participants were given opportunities for revisions, feedback, assessment dialogues, and evaluations. Participants in the control condition conducted their writing assignments without the formative assessment interventions and training on developing self-regulation. They conducted the writing assignments in the same way as they did it in previous years. Participants did not explicitly receive previously established criteria or standards for writing tasks. The instruction of the writing assignments started with providing skills instruction. The teacher explained the assignment; in particular with regard to characteristics of the texts in the genre students were to write in. The students did not discuss requirements or criteria, nor did they receive rubrics. Students wrote their own texts, which were completed in class. Finally, the teacher checked the assignments, marking them for content, grammar, spelling and organization.

TABLE 2 | Timeline.

Pretest time 1	Interventions	Posttest time 2	Vacation	Follow-up time 3
January: Week 1	February until May	June: Week 22	July-August	September: Week 32
Essay on persuasion followed by pretest questionnaires (ILS and STPQ)	Writing assignment 1 - Clarify criteria - Checklist - Evaluation (either peer or self) Writing assignment 2 - Clarify criteria - Checklist - Evaluation (either peer or self) Writing assignment 3 - Clarify criteria - Checklist - Evaluation (either peer or self)	Essay on remembering primary school followed by posttest questionnaires (ILS and STPQ)	—	Essay on holiday experiences followed by follow-up questionnaires (ILS and STPQ)

The students did not revise their assignments according to their teacher's feedback, nor did they receive any process-oriented instruction or cognitive-strategy instruction. Over the intervention period, the participants completed three writing assignments in the same range of genres as the experimental conditions. A posttest was conducted at the end of the intervention period during the first 2 weeks of June. At the end of June, primary school was finished, and the summer holidays started. Ten weeks later, after an 8-week summer break, all participants were approached again and instructed to complete the follow-up questionnaire online. After 2 weeks, reminders were sent to collect missing questionnaires, and secondary school teachers were asked to remind and stimulate their students to complete the questionnaire. On the three measurement occasions, 695 (100%), 695 (100%), and 580 (83.5%) students completed the questionnaires, respectively.

Measures
Regulation and Motivation: The Inventory Learning Style Questionnaire

The Inventory Learning Style Questionnaire (ILS, Slaats, 1997) is a standardized instrument that is used to measure learning behavior. It can be used to examine how students think about their learning, and the extent to which students have self-regulated learning skills. The ILS was originally developed for students in vocational education. It consists of grammatically easy and comprehensible statements. Before using this ILS-scale, a pilot was conducted among 100 sixth-grade primary school students (not participating in this current study) to investigate the usability of the questionnaire for primary school students. Scale reliabilities in the pilot-study revealed a reasonable-to-good reliability (self-regulation: 0.76, external regulation: 0.68, intrinsic motivation: 0.90, extrinsic motivation: 0.85). Documented

reliability ranged between 0.68 and 0.90 of the subscales (Slaats, 1997).

The whole questionnaire consisted of four topics: general information processing, regulation activities, conceptions of learning, and motivation. This study used the topics dealing with regulation activities and motivation, which were divided into the following subscales: 1) self-regulation, 2) external regulation, 3) intrinsic motivation, and 4) extrinsic motivation. Self-regulation refers to the student-initiated regulation of strategies and activities, such as planning, adjusting, monitoring, and evaluating their own learning. An example statement included in the self-regulation scale is "I evaluate myself on whether I have performed a task correctly". External regulation concerns dependence upon teachers or other external sources to regulate and control the learning process. An example statement in the external regulation scale is "To know how I have performed a task, someone else needs to look at it". Motivation is operationalized in intrinsic and extrinsic motivation. Intrinsic motivation concerns being personally interested in a subject and feeling motivated to develop competence at it. This scale consists of statements such as "I want to attend this secondary school, because I am appealed by their educational program". Extrinsic motivation refers to emphasizing the instrumental value of education rather than the content, resulting in statements such as "I learn because it increases my chances in the future". Students were asked to respond to questions regarding regulation and motivation on a 5-point Likert scale ranging from (1) "I don't agree at all" to (5) "I totally agree." **Table 3** presents the scales and the number of items in each scale. Reliability ranged from 0.77 to 0.88.

Self-Efficacy for Task Performance Questionnaire

The Self-Efficacy for Task Performance Questionnaire (STPQ, Van Meeuwen et al., 2012) is a standardized instrument that

TABLE 3 | Reliability ILS (Slaats, 1997) and STPQ (Van Meeuwen et al., 2012).

	Number of items	Pretest scores N = 695			Posttest scores N = 695 (response rate 100%)			Follow-up N = 580 (response rate 83.5%)		
		α	Mean	SD	α	Mean	SD	α	Mean	SD
1. Self-regulation	9	0.82	2.72	0.76	0.88	3.09	1.19	0.86	3.15	0.65
2. External regulation	9	0.77	2.69	0.84	0.77	2.66	0.70	0.74	2.76	0.57
3. Intrinsic motivation	6	0.82	3.73	0.28	0.79	3.89	0.56	0.80	3.97	0.66
4. Extrinsic motivation	6	0.82	3.74	0.42	0.83	4.05	0.20	0.87	4.20	0.70
5. Self-efficacy	20	0.84	3.48	1.31	0.81	3.46	1.16	0.85	3.63	0.44

TABLE 4 | Correlation matrix for the variables self regulation, intrinsic motivation, and self-efficacy on the follow-up.

Variable	1	2	3	4	5
1. Self regulation	—	0.09*	0.25**	0.12**	0.39**
2. External regulation	—	—	0.08	0.12**	0.02
3. Intrinsic motivation	—	—	—	0.51**	0.39**
4. Extrinsic motivation	—	—	—	—	0.37**
5. Self-efficacy	—	—	—	—	—

*$p < 0.05$; **$p < 0.01$.*

measures self-efficacy. The questionnaire consists of 20 items. An example statement included in the self-efficacy scale is "I am not sure which learning strategies are most appropriate for this task". Answers on all questions were given based on a 5-point Likert scale ranging from (1) "I don't agree at all" to (5) "I totally agree". The scale had a reasonable reliability of 0.84 (**Table 3**).

Dealing With Missing Values and Nested Data

During the course of the study, 115 children (17%) dropped out due to external circumstances, such as moving, illness, technical errors, or absence during the last measurement. Therefore, some students were not able to complete all of the items on the questionnaires at all measurement occasions across the 9 months of the experiment. It is common practice to remove cases with missing values from the sample (listwise deletion). However, this practice has extensively been criticized (Little and Rubin, 1989). Therefore, missing values were allowed to be missing at random (MAR). A MAR test indicated that data were missing at random (χ^2 (3) = 7.07; p = 0.22). The loss of data was unsystematic and comparable across conditions. This similarity means that the missing value pattern was non-informative, that is, children who left the study did not introduce significant bias. To deal with missing values in this study, an appropriate strategy was developed. Multiple imputation (MI) of missing values was incorporated to lead to valid results (Schafer and Graham, 2002). The imputation of the missing values was achieved with the NORM program (Schafer and Graham, 2002). Then, all investigated variables were used in the generation of estimations.

In this study, a multilevel approach was chosen, since the observations made were not independent from one another and occurred over various time points. The multilevel analysis makes it possible to calculate the variance proportions at the individual, class, and school levels (Hox, 2002). In the current study, the data set was analyzed using IBM SPSS (version 21).

Data Analysis

First, the data were explored by investigating the overall average scores in the three conditions. A Pearson correlation was conducted to measure the strength and direction of a linear relationship between the variables; **Table 4** presents information about the correlations among variables. It was discovered that the variables of self-regulation, intrinsic motivation, and self-efficacy were significantly positively correlated at the last measurement.

The student responses were analyzed with a multilevel linear mixed model. The data in this study had a clear hierarchical structure: Student scores are nested within 17 schools. According to Hox (1995), students attending the same schools have more in common than students who go to another school, because students share experiences by being part of the same class. The analyses initially included class level, but the variance between school level and class level was not significant, consistent with the low intraclass correlation (ICC) for the variables self-regulation (0.015), external regulation (0.094), intrinsic motivation (0.036), extrinsic motivation (0.052), and self-efficacy (0.061). Thus, class level was not included. Secondary schools were not included as a third level because the follow-up was conducted at the beginning of secondary education; thus, students had not much experience with their secondary school at that stage. The following factors were consistently included in the model: pretest scores (i.e., self-regulation, external regulation, intrinsic motivation, extrinsic motivation and time as covariates), posttest scores (i.e., self-regulation, external regulation, intrinsic motivation, and extrinsic motivation as dependent variables), and follow-up scores (i.e., self-regulation, external regulation, intrinsic motivation, and extrinsic motivation as dependent variables). Condition was included as fixed factor. In addition, random intercepts for schools were included in the model. No abnormal departures from normality were found. The average responses were in the middle-to upper-scoring regions.

TABLE 5 | Results (mean and SD) of the ILS questionnaire and STPQ questionnaire at pretest, posttest, and follow-up.

Scales	Intervention Condition	Pre-test scores		Post-test scores		Follow-up scores	
		M	SD	M	SD	M	SD
1. Self-regulation	Condition 1 (*n* = 185)	2.68	0.58	3.43	0.49	3.31	0.54
	Condition 2 (*n* = 231)	2.70	0.57	3.45	0.45	3.41	0.57
	Condition 3 (*n* = 279)	2.81	0.70	2.67	0.58	2.78	0.63
2. External regulation	Condition 1 (*n* = 185)	2.73	0.71	2.74	0.69	2.84	0.57
	Condition 2 (*n* = 231)	2.66	0.64	2.70	0.56	2.74	0.57
	Condition 3 (*n* = 279)	2.69	0.65	2.60	0.58	2.72	0.57
3. Intrinsic motivation	Condition 1 (*n* = 185)	3.70	0.65	3.91	0.59	4.03	0.60
	Condition 2 (*n* = 231)	3.66	0.60	4.02	0.59	4.00	0.60
	Condition 3 (*n* = 279)	3.74	0.63	3.77	0.59	3.85	0.73
4. Extrinsic motivation	Condition 1 (*n* = 185)	3.74	0.68	4.06	0.68	4.23	0.71
	Condition 2 (*n* = 231)	3.69	062	4.13	0.69	4.19	0.71
	Condition 3 (*n* = 279)	3.78	0.65	4.01	0.61	4.19	0.69
5. Self-efficacy	Condition 1 (*n* = 185)	3.52	0.43	3.48	0.41	3.69	0.39
	Condition 2 (*n* = 231)	3.56	0.47	3.48	0.43	3.64	0.45
	Condition 3 (*n* = 279)	3.49	0.41	3.43	0.44	3.59	0.45

Note. Condition 1 = self-assessment intervention; Condition 2 = peer-assessment intervention; Condition 3 = control condition.

TABLE 6 | Fixed Effects for Predictors of Self-Regulation, External regulation, Intrinsic motivation, Extrinsic motivation, Self-efficacy.

Parameter	Self-regulation		External regulation		Intrinsic motivation		Extrinsic motivation		Self-efficacy	
	df	F	df	F	df	F	df	F	df	F
Intercept	197.83	880.92*	389.73	521.22*	572.55	713.15*	449.73	732.33*	676.71	533.31*
Condition	26.25	58.53*	24.66	2.32	24.26	7.09*	23.43	2.11	856.97	0.20
Time	1,140.04	0.65*	1,143.13	8.15*	1,141.33	3.88*	1,140.93	11.70*	1,140.96	54.37*
Pretest score	1,147.69	219.13*	1,148.48	245.16*	1,149.61	100.98*	1,149.99	142.57*	1,142.59	214.93*
Condition × Time	1,140.05	12.29*	1,143.08	1.07	1,141.25	4.42*	1,149.99	2.28	1,140.96	2.06

*p < 0.05.

RESULTS
Effects of the Formative Assessment Intervention on Self-Regulation and External Regulation After the Transition to Secondary Education

We hypothesized that the accomplished effects of the formative assessment intervention on self-regulation among sixth graders would significantly decrease after the transition to secondary school, despite the training of self-regulation skills in primary education. **Table 5** presents the scores per condition.

The multilevel analysis showed significant main effects of the formative assessment intervention on self-regulation for condition, pretest scores self-regulation, and significant interaction between condition and time (**Table 6**). **Table 7** shows the *B*-values for the main and interaction effects. Significant effects were found for pretest scores self-regulation and school type.

In line with the significance condition presented in **Table 6**, the significance condition in **Table 7** seems to indicate that participants in the self-assessment condition and peer-assessment condition showed significant effects, contrary to participants in the control condition, who showed no significant effects. At the posttest (Time 2), significant effects

were found, but Time 3 revealed no significance. Investigating the interaction effect between condition and time further, the factors condition and "time" (i.e., Time 2 = self-regulation posttest scores, Time 3 = self-regulation follow-up test scores) revealed significant effects among participants in the self-assessment condition and peer-assessment condition at Time 2. Interaction between the self-assessment condition and Time 3 and interactions between the peer-assessment condition and Time 3 (**Table 7**) revealed no significant effects, indicating that there was no decrease in self-regulation from the posttest (Time 2) to follow-up test (Time 3). Finally, the interactions between control condition and time showed there was no significant interaction within this condition, neither at Time 2 nor at Time 3. Random intercepts for school were significant.

The hypothesis that developed external regulation by means of formative assessment would not be affected after the transition was also tested with multilevel analysis. Results revealed no significant effects on condition (**Table 6**), and no interactions were found between condition and time. The analysis did show significant main effects for pretest scores external regulation and time.

Table 7 shows the B-values for the main and interaction effects on external regulation scores. Significant effects were found for pretest external regulation scores and time (**Table 6**). However,

TABLE 7 | Fixed effects estimates and covariance estimates of self-regulation scores, external regulation, intrinsic motivation, extrinsic motivation and self-efficacy.

Variabele	Self-regulation		External regulation		Intrinsic motivation		Extrinsic motivation		Self-efficacy	
	β	SE	β	SE	B	SE	β	SE	β	SE
Level 1	Fixed effects		Fixed effects		Fixed effects		Fixed effects		Fixed effects	
Intercept	1.96**	0.09	1.64**	0.09	2.77**	0.12	2.90**	0.12	2.25**	0.09
S.A. condition	0.40**	0.08	0.05	0.07	0.28*	0.08	0.08	0.09	0.06**	0.06
P.A. condition	0.49**	0.09	0.07	0.07	0.10**	0.08	0.06	0.09	0.01	0.06
Control condition	0.14	0.08	0.03	0.07	0.02	0.09	0.05	0.08	0.02*	0.06
Time 2	−0.32**	0.05	−0.14*	0.05	−0.06*	0.05	−0.18*	0.06	−0.13*	0.04
Time 3	−0.5	0.04	−0.15	0.08	0.12	0.06	−0.14	0.09	−0.13	0.05
Pretest scores	0.48*	0.02	0.39**	0.02	0.28**	0.02	0.32**	0.05	0.39**	0.02
S.A. × Time 2	0.44**	0.07	0.09	0.07	−0.11*	0.08	0.04	0.09	−0.06	0.05
S. A × Time 3	0.16	0.08	0.01	0.08	0.05	0.09	−0.05	0.09	0.09	0.06
P. A. × Time 2	0.44**	0.08	0.10	0.07	0.11*	0.08	0.18	0.08	0.04	0.05
P.A × Time 3	0.12	0.08	0.13	0.07	0.01	0.09	−0.03	0.09	0.02	0.06
Control × Time 2	0.09	0.06	0.03	0.05	0.09	0.05	0.12	0.09	0.07	0.05
Control × Time 3	−0.04	0.08	−0.05	0.09	0.05	0.09	−0.08	0.11	0.09	0.06
Level 2	Random parameters		Random parameters		Random parameters		Random parameters		Random parameters	
—	cov	SE	cov	SE	cov	SE	cov	SE	cov	SE
Intercepts Primary schools	0.02*	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01*	0.01
Residuals	0.25**	0.01	0.28**	0.01	0.35 **	0.01	0.39**	0.02	0.14**	0.01
Model Fit	−2Restricted LogLikelihood = 1,61.37		−2Restricted LogLikelihood = 1,864.84		−2Restricted LogLikelihood = 2,128.35		−2Restricted LogLikelihood = 2,229.55		−2Restricted LogLikelihood = 1,096.17	

*$p < 0.05$. **$p < 0.10$.

there seems to be no decrease in external regulation scores after the transition in any of the intervention conditions: none of the conditions were affected by the intervention on external regulation scores, nor did scores differ significantly between conditions; both condition and time revealed no significant effects. There were no significant interactions between Times 2 and 3 and the self-assessment condition, peer-assessment condition, or control condition. Random intercept for schools showed no significance.

Effects of the Formative Assessment Intervention on Intrinsic and Extrinsic Motivation After the Transition to Secondary Education

The second research question examined the effects of the formative assessment intervention on intrinsic and extrinsic motivation after the transition to secondary education. **Table 6** shows a significant main effect for intrinsic motivation for each condition, time, pretest scores intrinsic motivation, and interaction between condition and time. **Table 7** shows the B-values for the main and interaction effects on intrinsic motivation. Significant effects were found for pretest scores intrinsic motivation. With regard to condition, the results indicated that participants in the self-assessment condition and peer-assessment condition showed significant effects. In the control condition, no significant effects were found for intrinsic motivation. Significant effects were found at Time 2, whereas Time 3 revealed no significance. In addition, the

interaction effects between condition and time were further explored. The factors condition and time revealed significant differences among participants in the self-assessment condition and peer-assessment condition at Time 2. The interaction between the self-assessment condition and Time 3, as well as the interaction between the peer-assessment condition and Time 3 (**Table 7**) revealed no significant effects; there was no decrease in intrinsic motivation from Time 2 to Time 3. The interactions between the control condition and time showed no significant interaction within this condition, neither at Time 2, nor at Time 3. Random intercepts for school were not significant.

Regarding the extrinsic motivation scores, the hypothesis that extrinsic motivation would decrease after the transition was also tested with multilevel analysis. The analysis showed significant effects for time and pretest scores extrinsic motivation (see **Table 6**). No significant effects were found for condition. In addition, the results did not show a significant interaction effect between condition and time. **Table 7** shows the B-values for the main and interaction effects on extrinsic motivation scores. Significant effects were found for pretest extrinsic motivation scores and Time 2. There seems to be an increase in extrinsic motivation scores after the transition. There were no significant effects found for the self-assessment condition, peer-assessment condition, or control condition. The results indicate no significant differences between conditions, nor were significant interactions found between Times 2 and 3 and the self-assessment condition, peer-assessment condition, and control condition. Random intercepts for school showed no significance.

Effects of the Self- and Peer-Assessment Interventions on Self-Efficacy After the Transition to Secondary Education

For self-efficacy, the multilevel analysis showed significant main effects for time, condition and pretest scores self-efficacy (**Table 6**). The multilevel analysis revealed no significant interaction between condition and time. **Table 7** shows the B-values for the main and interaction effects of self-efficacy. The analysis showed significant effects of pretest scores self-efficacy and time. In line with the significance condition presented in **Table 6**, the significance condition in **Table 7** showed significant effects in the self-assessment condition. Contrary to the peer-assessment condition and control condition, in this condition no significant effects were found.

At Time 2, significant effects were found, but Time 3 revealed no significance. Thus, the interaction effects between condition and time were further explored. The factors condition and time revealed no significant differences between conditions and time. The interactions between conditions and Time 2 and conditions and Time 3 indicated no differences in self-efficacy scores. Random intercepts for school were significant.

CONCLUSION AND DISCUSSION

This study aimed to examine the effects of a formative assessment intervention in primary education on the self-regulation, motivation and self-efficacy, after the students' transition to secondary education.

The first research question was "What are the effects of the formative assessment intervention on self-regulation and external regulation after transition to secondary education?" Based on previous research on self-regulation in secondary education, it was hypothesized that the accomplished effects of the formative assessment intervention on self-regulation among sixth graders significantly decreased after the transition to secondary school. The results in this study, however, show no significant differences between the follow-up test scores (Time 3) in the self-assessment condition or peer-assessment condition, for the accomplished effects of the intervention on self-regulation scores on Time 2. Not only were no significant interaction effects found between intervention conditions and Time 3, the results indicate no decrease in previously acquired self-regulation skills. Thus, primary school students who have benefitted from developing self-regulation skills by means of formative assessment in upper primary education remain having those acquired self-regulation skills after their transition to secondary education. Also, students in the control condition, who did not benefit from self-regulation development in primary education, showed no change after the summer holiday. The control condition showed no significant effects at Time 2 and remained equally stable in their lower self-regulation scores after the transition at Time 3.

The longitudinal effects of the assessment intervention on external regulation were explored. In this study, it was not expected that students' external regulation would differ after the transition. The results showed, in line with the hypothesis,

no significant main or interaction effects on external regulation, condition, and time. According to Cleary (2004), developing self-regulation could result in a decrease of dependence on external sources by students. These findings suggest that the processes of external regulation during the development of self-regulation and its interaction need to be further examined.

The second research question focused on the effects of formative assessment on intrinsic and extrinsic motivations after the transition. It was hypothesized that both intrinsic and extrinsic motivation would decrease after the transition to secondary school. Although several studies have shown a decrease of learning motivation over the years, the results in this study showed no significant differences in either one of the intervention conditions. This indicates that there is no decrease in intrinsic motivation. Primary school students who have benefitted from the formative assessment intervention in upper primary education were equally intrinsically motivated after their transition to secondary education as they were at the end of sixth grade. Students in the control condition showed no significant interaction effects on intrinsic motivation at Times 2 or 3. These results converge with studies about the benefits of self-regulation on motivation and about increasing motivation by means of self-regulation (Cleary and Zimmerman, 2004; Spinath and Spinath, 2005). Given that there was no decrease in self-regulation due to the positive effects of the formative assessment intervention that lasts after the transition, unsurprisingly no effects were found for intrinsic motivation. This corresponds with the correlation found between self-regulation and motivation.

With regard to expectations for extrinsic motivation, no significant differences were expected. Pretest scores of extrinsic motivation were significant. Students' extrinsic motivation increased at the entrance of secondary education among all students. No significant effects were found for condition, time, and interactions between condition and time. The formative assessment intervention did not significantly affect extrinsic motivation in primary education, but after the transition changes occurred. Although there is a noticeable increase extrinsic motivation scores after the transition, underlying factors of the development in secondary education are not well understood and need to be further explored.

The third research question aimed at exploring the effects of the formative assessment intervention on self-efficacy. According to Spinath and Spinath (2005), a decrease in self-regulation and learning motivation is paralleled by a decrease in competence beliefs and a lack of sufficient learning strategies. Previous studies on the effects of formative assessment intervention on self-efficacy only partially supported the assumption that self-efficacy would be affected due to formative assessment (Meusen-Beekman et al., 2015). A decrease in self-efficacy after the transition in both formative assessment intervention conditions was hypothesized. Indeed, it seems that there was no significant main effect in the peer-assessment condition. However, the main effects in the self-assessment condition and control condition were significant. Interaction effects between condition and time were not significant. These results are in line with previous research, which showed no direct effect of

formative assessment on self-efficacy (Alonso-Tapia and Panadero, 2010).

Based on the findings, the conclusion is that not only the development of a self-regulation strategy repertoire by means of formative assessment in primary education seems to be effective, but the effects also remain stable after the transition to secondary education. Developing self-regulation by means of formative assessment in primary education is emphasized, and can contribute to preventing deficits in self-regulation and motivation. The results of the present study are conditional upon certain choices in the research design and procedure. Subsequently, practical and methodological limitations will be addressed, and directions for future research are given. In this large manipulation, measures were based on self-perceived estimations of self-regulation skills, motivational beliefs, and self-efficacy. The self-report questionnaires, ILS and STPQ, were used in this intervention, because both are standardized validated self-report measures. However, general scales for specific usage may have led to lower correlations between ILS and STPQ items. There is a possibility that school-level influences the degree and development of self-regulation. This limitation should be taken into account when considering the extent to which the results can be generalized. Since multilevel analysis involves two or more levels, questions concerning optimal sample sizes are difficult to answer, and the best advice will also depend on the purpose. Hox et al. (2010) mentions Kreft's 30/30 rule, which means 30 conditions with a least 30 individuals in each. This could be sufficient for the estimation of the regression coefficients but inadequate for other purposes. If it is cross-level interactions that are of interest, Hox recommends the 50/20 rule: 50 conditions with 20 or more in each condition. If there is strong interest in the random part, the advice is 100 conditions with a minimum of ten in each. This study involves 17 schools with approximately 40 participants. These numbers do not entirely meet the requirements. Despite these limitations, the study provides promising results.

Considering the significance of self-regulation for students' abilities to learn, academic outcomes, motivation, and self-efficacy, this large manipulation contributes to the knowledge base concerning longitudinal development of self-regulation from primary education throughout secondary education. Results from several studies (Van der Veen and Peetsma, 2009; McMillan et al., 2017; Greene, 2020) show substantial differences in both self-regulation and motivational variables during the course of school years. This study provides long-term effects of formative assessment interventions on self-regulation, motivation, and self-efficacy and supports educators who wish to enhance their students' motivation and self-regulation through formative assessments.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Open Universiteit, Netherlands, Heerlen. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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