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A Dynamic Analysis of the Interplay between Asynchronous and Synchronous Communication in Online Learning: The Impact of Motivation

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Abstract

With the increased affordances of synchronous communication tools, more opportunities for online learning to resemble face-to-face settings have recently become available. However, synchronous communication does not afford as much time for reflection as asynchronous communication. Therefore, a combination of synchronous and asynchronous communication in e-learning would seem desirable to optimally support learner engagement and quality of student learning. It is still an open question though, how to best design online learning with a blend of synchronous and asynchronous communication opportunities over time. Few studies have investigated the relationship between learners' actual use of synchronous and asynchronous communication over time. Therefore, this study addresses that relationship in an online course (N = 110), taking into account student motivation, and employing a dynamic intertemporal perspective. In line with our assumptions, we found some support for the expected association between autonomous motivation and engagement in asynchronous and synchronous communication, be it restricted primarily to the first course period. Also, positive relations between engagement in synchronous and asynchronous communication were found, with the strongest influence from using asynchronous to synchronous communication. This study adds to the knowledge base needed to develop guidelines on how synchronous communication can be combined with asynchronous learning.

1. Introduction

Recent developments in computer-assisted learning show an increase in the use of synchronous communication tools that offer more resemblance to face-to-face interaction. Widely available web-videoconference tools like Skype and ooVoo offer real-time communication through (a combination of) audio, video, and chat. This can be seen as a welcome addition to 'traditional' text-based asynchronous communication means in blended and online education, as findings from research in computer-mediated communication (CMC) show that different features of both synchronous and asynchronous communication may be beneficial in supporting different pedagogical aims (Pfaffmann, 2007; Hrastinski, Keller, & Carlsson, 2010). For example, it has been argued that asynchronous communication allows for more time to reflect on a contribution and refine it than synchronous communication (Davidson-Shivers, Muilenburg, & Tanner, 2001). However, Paulus (2006) argued that in text-only online environments even experienced online learners may have difficulties in conveying their message in a constructive manner. Indeed, it has been shown that asynchronous communication often leads to a misinterpretation of written contributions (like a post on a discussion forum) because of a lack of shared context, body language, or writing style (Bromme, Hesse, & Spada, 2005). In addition, learners may feel less engaged if only asynchronous communication is used, as is reflected by general findings that both quantity and quality of contributions to discussion forums often differ greatly across individual learners, depending on their motivation (Rienties, Tempelaar, Van den Bossche, Gijselaers, & Segers, 2009; Järvelä, Volet, & Järvenoja, 2010; Schellens & Valcke, 2005).

Synchronous communication tools such as web-videoconferencing allow for more direct social interaction and feedback amongst learners and teachers, which may leave less time for reflection but do allow for direct correction of misconceptions, and may lead to higher levels of learner engagement (Carr, Cox, Eden, & Hanslo, 2004, Hrastinski et al., 2010; Strømsø, Grøttum, & Lycke, 2007). Therefore, one would expect that the combination of synchronous and asynchronous communication in online learning would better support learner engagement and the quality of student learning than using only asynchronous communication (Hrastinski et al., 2010; Graham, 2006; Johnson, 2006). For example, Hrastinski et al. (2010) researched how synchronous online communication can support e-learning processes by taking multiple design exemplars as a basis. Findings include a positive effect of synchronous communication on the support of group-wide relations, strengthening weak class-wide relations, and social support. An intermediate to strong influence of synchronous communication for task support was found. Amongst others, Hrastinski et al. (2010) concluded that it is impossible to provide a success recipe for the application of synchronous communication as its characteristics (based on text, audio, video, or a combination) can differ highly. They suggest letting the choice of communication media to be dependent of the way in which it can support the educational processes.

The initial positive findings of using synchronous communication in support of different contexts are promising and justify further research on applications in other designs of online learning. In addition, Johnson (2006) concluded in his literature review on the use of text-based synchronous and asynchronous communication, that asynchronous discussion is equal to or may be better than synchronous discussion to foster student satisfaction of course requirements. Next, he showed that students do not have a preference for one communication mode or the other. Further, he found that while participation in asynchronous discussion requires more of students' autonomy, it results in a retraceable backlog of the constructed knowledge. Synchronous communication, in turn, is more direct in the support of social processes. As both modes have their own specific merits, Johnson (2006) argued combining both modes may offer the best of both to enhance the online learning process. That is, direct feedback and support of social processes may best be supported through synchronous discussion, while asynchronous discussion may best support the development of higher-level thinking skills, for example, through the process of writing and enhanced reflection time. However, little is known about how to combine synchronous and asynchronous communication over time, in a way that effectively enhances student learning (Strømsø et al., 2007; Graham, 2006).

In addition, CMC research has suggested that the actual use of both synchronous and asynchronous communication tools and the resulting interactions in an online learning situation are related to individual differences between learners, and specifically strong relations have been found with motivation or self-determination (Rienties et al., 2009; Järvelä, Hurme, & Järvenoja, 2011; Roca & Gagné, 2008; Sørebø, Halvari, Gulli, & Kristiansen, 2009). Concluding an elaborated review of CMC in education, Luppicini (2007) argued that to increase our understanding of new CMC dimensions (e.g. web-videoconferencing) that did not exist ten or twenty years ago, researchers should approach CMC as a complex system encompassing multiple factors from an inter-temporal point of view. Though some studies are available on the inter-temporal development of virtual teams in organization settings (e.g. Kanawattanachai, & Yoo, 2007; Maznevski, & Chudoba, 2000), there are only a few studies on online learning that take the time aspect into account. Even fewer studies provide useful insights for the use of combined communication modes. For example, Akyol, Vaughan, & Garrison (2011) compared two implementations of the same online graduate course on education, but with different duration (6 vs. 13 weeks). Communication took place asynchronously. Differences in group cohesion between the two courses were found, but could not be attributed to the difference in duration as group dynamics were argued to have the strongest influence. In their conclusion, Akyol et al. (2011) primarily point toward the importance of a course design that is reliable and coherent from the start of an online course onward. This conclusion is also supported by a study by Akyol and Garrison (2008) in the context of an online graduate course on blended learning that used combined synchronous and asynchronous communication. Collaborative activities were shown to increase group cohesion and students' sense of belongingness over time. Though this was not found to influence learning, it did influence student satisfaction with the course. Furthermore, the design of the course and the development of related aspects like direct instruction over time were shown to significantly influence learning.

Furthermore, Rienties, Tempelaar, et al. (2012) analysed the development of asynchronous group discussions over time by making a distinction in the level of learners' self-determination. Findings showed that in an early stage of the course, autonomy-oriented learners (i.e. learners with an intrinsic drive who can effectively steer their own learning) engaged significantly more in both task-related and non-task related discourse than control-oriented learners (i.e. learners with an external drive, who are less efficient in steering their learning process). Over time (2-3 weeks), the autonomy-oriented learners focused their discussion away from non-task related to task-related discourse, while the control-oriented learners did not. Interestingly, at an early stage in the course, autonomy-oriented learners already developed a preference to connect to other autonomous learners. Rienties, Tempelaar et al. (2012) suggested that this dynamic may have put control-oriented learners (for whom engagement already is a challenge) in an additional disadvantaged position already at an early stage in the course. Similar to Akyol and Garrison (2008) and Akyol et al. (2011), they conclude that from the start of an online course, the learning environment and learning processes should provide sufficient structure and autonomy support (e.g. via scaffolding) to enhance engagement of all learners.

Although the number of studies addressing the time aspect of asynchronous communication (Akyol, & Garrison, 2008; Akyol et al., 2011; Rienties, Giesbers, Tempelaar, Lygo-Baker, Segers, & Gijselaers, 2012; Rienties, Tempelaar, et al., 2012), and the use of synchronous communication (Giesbers, Rienties, Tempelaar, & Gijselaers, 2013; Hrastinski, 2008; Hrastinski et al., 2010) in online learning has increased in the last years, to the best of our knowledge not a single study has investigated how learners balance the use of synchronous and asynchronous communication during the runtime of an online course, and how these decisions are related to learners' degree of self-determination.

We therefore investigated the relationship between the use of synchronous and asynchronous communication over time, by 110 participants in an online course, and how this was affected by student motivation. Performance on a final exam was also taken into account in order to address the question of how the relationships between the use of different communication tools and motivation affected learning outcomes; prior studies have shown that higher autonomy oriented motivation in e-learning leads to better learning outcomes (Rienties, Giesbers, et al., 2012). The findings of this study add to the knowledge base on how to combine asynchronous and synchronous communication in online learning in a way that effectively influences student learning. Before discussing the relationship between synchronous and asynchronous communication and motivation in e-learning in more detail, we will first discuss the role of motivation in e-learning, as conceptualized by Self-Determination Theory (SDT; Deci & Ryan, 1985, 2002; Ryan & Deci, 2000).

1.1 Online Learning and Self-determination

A factor that has been found to have a large influence on learning behaviour in both offline and online educational settings is self-determination (Rienties et al., 2009; Chen & Jang, 2010). Self-determination refers to learners' perception of the extent to which learners can steer their own learning process and is therefore strongly related to motivation as it "is specifically framed in terms of social and environmental factors that facilitate versus undermine intrinsic motivation" (Ryan & Deci, 2000, p. 58). In SDT (Deci & Ryan, 1985, 2002; Ryan & Deci, 2000), a distinction is made between autonomy-oriented learners, who typically are intrinsically motivated and engage in learning because it is perceived as an enjoyable or challenging activity; and control-oriented learners, who show a strong disposition for extrinsic motivation and feel they have limited control over their learning process. The third orientation is the impersonal orientation, which is held by learners who neither have an internal or externally locus of control of their learning, and this orientation is therefore associated with amotivation. The autonomous and control orientations are not seen as mutually exclusive categories: extrinsic motivation, for instance, is perceived as a continuum of types that differ in how close they are to intrinsic motivation and vice versa (Deci & Ryan, 2002). Amotivation, obviously, is seen as distinct from the other two.

SDT states that learners' motivation and well-being are determined by the extent to which three basic needs are satisfied: the need for autonomy (i.e., learners' perception of the amount of control they have over the learning process), the need for relatedness (i.e., learners' perceived amount of social inclusion), and the need for competency (i.e., how learners perceive their ability to deal with learning activities). All three needs are affected by contextual factors, like the interaction between learners, teachers, and the learning materials (Ryan & Deci, 2000).

Several scholars have argued that the role of self-determination in the complex dynamics of online learning is not well understood (Rienties et al., 2009; Järvelä et al., 2010; Martens, Gulikers, & Bastiaens, 2004). Online learning settings are much more open and flexible than classroom settings, because they offer a limited amount of external regulation and structure, and thereby allow a learner to be more autonomous in making choices regarding their learning behaviours (Chen & Jang, 2010; Chen, Jang, & Branch, 2010). This requires more self-determination from a learner and because of this, not all learners are able to learn efficiently in online setting (Kirschner & Erkens, 2013; Liu, Horton, Olmanson, & Toprac, 2011). Nevertheless, even though processes such as monitoring learners' activity, providing timely feedback, and fostering learners' sense of competence, autonomy, and relatedness are different in online learning (Chen & Jang, 2010), it can be done, especially when synchronous communication tools are used. Offering autonomy support and structure has been shown to profoundly influence student engagement both in classroom (Guay, Ratelle, & Chanal, 2008; Jang & Deci, 2010) and in e-learning settings (Rienties, Tempelaar, et al., 2012; Chen & Jang, 2010).

1.2 SDT and the Interplay between Asynchronous and Synchronous Communication

Findings from CMC research, which are primarily based on asynchronous communication, have found self-determination to influence student engagement and knowledge construction in online learning; more specifically, learners with stronger intrinsic or autonomous motivation have been found to learn more effectively in online settings (Rienties et al., 2009; Rienties, Giesbers, et al., 2012; Martens et al., 2004).

Moreover, adding synchronous communication to an online course further enhances the choices learners can make to steer their learning behaviour. Limited research is available about the effect of synchronous communication opportunities on the engagement in asynchronous communication, and it is therefore an open question whether such opportunities would replace or enhance the use of asynchronous communication, and whether this effect depends on learners' motivation. Hrastinski (2008) compared two cohorts of learners in a professional setting that used a combination of discussion forums and text-based chat. Findings included that using the synchronous text-based chat as a complement positively influenced student engagement in asynchronous discussions. The main explanation Hrastinski offered for this finding was that the synchronous communication made learners more aware of the activity of, and interaction with, other learners.

Translated in terms of SDT, this would mean that synchronous communication may increase learners' sense of relatedness by affording more direct and personal social interactions and feedback. Furthermore, synchronous communication, via the affordance to limit the delay in monitoring activity, may positively affect learners' sense of competency (e.g. by providing timely content related feedback by both learners and tutors), and the sense of autonomy (i.e. by providing timely process-related feedback). In turn, an increase in perceived autonomy, perceived competence, and perceived relatedness has been found to have a positive influence on learners' motivation to use ICT (Roca and Gagné, 2008; Sørebø et al., 2009). In other words, it might be hypothesized that the use of synchronous communication may enhance the use of asynchronous communication in online learning.

1.3 The Present Study

In line with previous research, we would argue that engagement in synchronous communication supports engagement in asynchronous communication. Also, we expect that learners with stronger intrinsic or autonomous motivation would engage more in both types of communication, and would show better knowledge construction both in terms of more task-oriented asynchronous discourse and in terms of better performance on a final test. To address the effects over time, the online course was divided into four periods, each characterised by a web-videoconference followed by a phase of asynchronous communication that incorporated the core of the collaborative knowledge construction. That is, the largest part of student-activity took place in the asynchronous discussion forums and reflected students' self-study of the literature (also see section 2.2.1). Each period lasted about a week; as the timing of the next web-videoconferences were planned collaboratively. The learning process Figure 1 shows the main variables in this study and the transition between course periods as the course progresses over time.

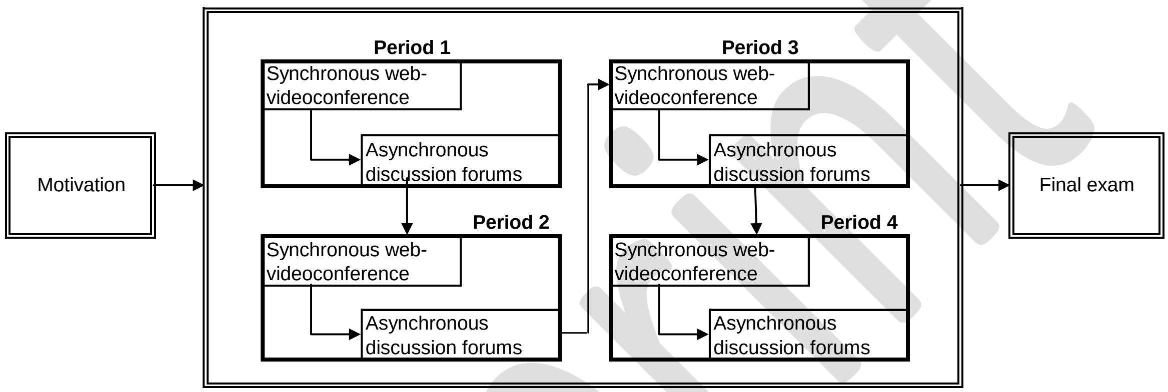

Figure 1. Model of the variables in this study

Regarding asynchronous communication, in line with previous findings regarding the relation between motivation and engagement in asynchronous discussions (Rienties et al., 2009; Rienties, Tempelaar, et al., 2012; Martens et al., 2004), we expect that engagement in asynchronous communication both in quality (more task-related posts) and quantity (more posts in general) would be positively associated with higher levels of autonomous motivation (H1a), in each period in the course (H1b).

In line with prior studies (Hrastinski, 2008; Hrastinski et al., 2010), we would expect that participation in the synchronous web-videoconferences would be associated with a higher number and a higher quality of contributions to the asynchronous discussion forums (H2a), for both autonomy-oriented learners as well as for control-oriented learners (H2b), and in each phase of the course (H2c). However, based on findings on self-determination (Roca and Gagné, 2008; Sørebø et al., 2009) we can expect that autonomy-oriented learners who participate in the web-videoconference to be more engaged in the asynchronous discussion forums in terms of both quality and quantity than control-oriented learners who participated in the web-videoconference (H3). After testing each of these hypotheses separately, a path analysis was also conducted, which does justice to the recommendations by Luppicini (2007) to approach CMC in education as a whole of complex interrelated factors over time.

2. Method

2.1 Participants and Context

Participants were students in a facultative summer course in economics for prospective Bachelor students of an international business and economics degree programme at a Dutch business school which was offered entirely online and aimed to bridge potential gaps in prior knowledge of economics (Rienties et al., 2006; 2009). The course was part of a wider summer course program that has been offered since 2004 to over a thousand participants, and has been integrated in the admission and application processes of the respective business school. The authors of this study were actively involved as course designers within the wider remedial program and two were actively involved as tutors in the economics course.

Students who subscribed to the Bachelor program received a letter that informed them of the possibility to participate in this course. The letter contained information about the course purpose and content as well as a link to a prior knowledge test with which students could assess the benefit they could get from the course. When students got a low score on the prior knowledge test but did not enrol for the course, they received a follow-up e-mail recommending enrolment. After enrolment, the course team assigned students at random to a small group in which they would work and learn together throughout the course.

Participants in this study came from two consecutive years of the same course, and the total number of groups was 11 (M group size = 14.09; range = 6-16). An entry questionnaire including demographic questions and a motivation questionnaire (see materials section) that was taken directly after enrolment showed no significant differences in gender, age, ICT skills, previous e-learning experience, and motivation between participants in the two cohorts. Most students reported to have intermediate ICT skills, and less than 10% had followed an online course before. Of the total number of 155 students, 45 students had not or only partly filled in the motivation questionnaire; as a consequence, only 110 students were included in this study (M age = 19.5; SD = 1.28; 39% female). No significant differences on the study variables between omitted and included students were found.

2.2 Materials and procedure

2.2.1 Online preparatory course

For this course, team collaboration was facilitated via a Microsoft Sharepoint based online environment that supported storage and delivery of the course manual and course materials, and supported asynchronous communication via discussion forums. Integration with Adobe Connect enabled the use of online web-videoconference, during which participants could communicate via (a combination of) audio, video, and chat (also see Giesbers, Rienties, Gijselaers, Segers, & Tempelaar, 2009). No special hardware was needed to access the course material and the discussion forums. For the use of audio-visual functionalities during a web-videoconference a regular webcam and/or headset was sufficient.

The course design was based on principles of Problem-Based Learning (PBL, see Loyens, Kirschner, & Paas, 2011) by letting groups of students collaboratively solve six authentic problems on basic economic concepts, micro-economics, and macro-economics (two problems each). The learning process was structured using the PBL Seven-Jump model (see Schmidt & Moust, 2000; Segers, van den Bossche, & Teunissen, 2003;) which was adapted slightly to accommodate the online setting (Rienties et al., 2009; Rienties, Giesbers, et al., 2012), and required students to: 1) identify difficult terms; 2) identify the main problem(s) and brainstorm to formulate learning goals; 3) start to solve the learning goals by referring to personal experience, course literature and/or additional literature; 4) elaborate on the findings in the previous step; 5) reach agreement on the answers through discussion, 6) check if all learning goals are answered and; 7) summarize the main points of the entire discussion. This process was guided by a tutor.

The course ran for a maximum of six weeks and had an estimated study load of 10 to 15 hours per week of which the majority was spent on asynchronous discussion forums. For each task, a dedicated discussion forum was available where students could post and discuss the learning goals connected to that particular task. At the beginning of each of the first four weeks, a web-videoconference was organised in addition to the forum discussions. The first web-videoconference started with a personal introduction by all participants, followed by an explanation of the content and procedures of the course. The second part consisted of a pre-discussion (Seven-Jump steps 1-3) of the introductory tasks. In the second meeting, the introductory tasks were post-discussed (Seven-Jump steps 4-7).

For example, the first task was on an introductory level and dealt with the case of a young girl from North Korea who comes to Maastricht to study economics. She is confused by the differences in economic systems she experienced and she is looking to find an overview that could explain the main players and their interaction in different economic systems. During the web-videoconference, the task was read and it was made sure everyone understood the used terms (Seven-Jump 1). This was followed by a discussion of the main problems and the formulation of learning goals (Seven-Jump 2). An example of a learning goal would be “Characterize the differences between different economic systems”. This learning goal was then discussed based on the experience and knowledge of participants (Seven-Jump 3). After the web-videoconference, students started to self-study the literature and continued the discussion of the learning goals in the discussion forums (Seven-Jump 3 and 4). During this period, additional learning goals may have come up (e.g. “Are the two dominant economic systems (planned economy and market economy) mutually exclusive or are there forms in between? Identify examples if possible.”), that could be answered during the asynchronous discussion. Also during this period, a date and time for the next web-videoconference were set based on availability as indicated in an online agenda containing multiple options. In the next web-videoconference, the task at hand was post-discussed by elaborating on and clarifying the self-study findings (Seven-Jump 4), reaching agreement on the answers through discussion (Seven-Jump 5), checking if all learning goals were answered (Seven-Jump 6), and summarize the main points of the entire discussion (Seven-Jump 7). A new pre-discussion of the next task was then started and the cycle continued. The implementation of web-videoconference is in line with Strømsø et al. (2007), who suggested that synchronous communication is most useful to support generating ideas, like was done during the pre-discussion (Seven-Jumps 2 and 3).

Because the course was facultative, participation in the discussion forums and web-videoconferences was also voluntary but encouraged by a rating (by the tutor) of each student's contributions which counted as 10% of that student's final grade for the course (which should not be confused with the final exam score used in this study).

With permission from the students, all web-videoconferences were recorded. These recordings could be watched by group members, which allowed students who had been unable to attend a particular videoconference to catch up with the key discussion points, but this option was only seldom used.

2.2.2 Final exam

All course topics were addressed in a final exam that consisted of 20 multiple choice items and one open item. The exam was voluntary and was completed by only 45.5% of the participants (n = 50), who did not differ from the other participants in terms of demographics nor motivational profile (see also Giesbers et al., 2013). Low retention rates are a common finding in online courses (Park & Choi, 2009; Rovai, 2003), and although the final exam was not the main focus of our study, we decided to include it as a variable in the path model (see section 3.3) to give further indication of student performance. We analysed the data both with and without inclusion of the final exam, which showed similar results.

2.2.3 Content analysis

A common way to analyse individual contributions to online discussion fora is content analysis (CA), in which the asynchronous discourse taking place is coded, using a validated coding scheme, to reveal evidence of knowledge transfer and learning (De Wever, Schellens, Valcke, Van Keer, 2006; Strijbos, Martens, Prins, & Jochems, 2006). In line with previous studies in asynchronous learning in this context (Rienties et al., 2009, Rienties, Tempelaar, et al., 2012) the coding scheme developed by Veerman and Veldhuis-Diermanse (2001) was used. The coding scheme employs non-task-related and task-related discourse as the main categories. Within the category non-task-related, messages are further divided into the categories 1) planning; 2) technical; 3) social; and 4) nonsense. Messages coded as task-related are further divided into the categories 5) facts; 6) personal experience; 7) theoretical ideas; 8) explication; and 9) evaluation. Appendix A provides examples for each of the coding categories and examples of messages.

The discourse material was analysed by two coders (both economists) who were trained in using the coding scheme and who received a financial compensation for their work. When there was a difference between the two coders, the first author acted as a third coder to assess the message. In total, 1766 messages were posted of which 1742 (98.6 %) proved to be codeable. Cronbach α scores for the coding of these messages was .907 which is well above the recommended value of .75 to .80 that is reported in most studies (see De Wever et al., 2006). Agreement between the two coders was assessed via Cohen's κ which, with a value of .640, was within the range of fair to good agreement (κ range .40 to .75), as argued by De Wever et al. (2006) and in line with previous studies (Rienties et al., 2009; Rienties, Tempelaar, et al., 2012).

2.2.4 Participation in the synchronous web-videoconferences

Based on findings by Hrastinski et al. (2010) and Johnson (2006), we were primarily interested in the relation between participation in synchronous communication and the main knowledge construction during the asynchronous communication process. Therefore, participation in the web-videoconferences was operationalized for each period by a dichotomous variable (0 = not participated, 1 = participated).

2.2.5 Academic motivation scale

At the beginning of the course, students' motivation was measured using the Academic Motivation Scale (AMS; Vallerand, 1997; Vallerand & Bisonnette, 1992), which is based on SDT (Deci & Ryan, 1985, 2002). The AMS consists of 28 items on a 7-point Likert scale divided into seven subscales. Three subscales concern intrinsic motivation: (1) motivation to know (IMTK, learning driven by the need to understand something new, Cronbach $\alpha = .82$); (2) motivation to accomplish (IMTA, learning driven by the need to accomplish something, $\alpha = .77$); (3) motivation to experience stimulation (IMES, learning driven by the need to experience stimulations, $\alpha = .81$). Three subscales concern extrinsic motivation and display a range on the continuum of self-determined behaviour from (1) identified regulation (EMID, which is closest to intrinsic motivation. Here, learning behaviour follows a conscious valuation of a goal or regulation, giving it personal importance; $\alpha = .60$), (2) introjected regulation (EMIN, where retaining self-worth is the prime reason for learning; $\alpha = .83$) to (3) externally regulated learning (EMER, where learning is steered through external means such as rewards, $\alpha = .85$). The final scale concerns amotivation (AMOT, $\alpha = .81$) or the absence of regulation that can be directed either external or internal. The reliability as reflected by Cronbach α scores is in line with previous studies (Fairchild, Horst, Finney, & Barron, 2005; Vallerand & Bisonnette, 1992; Vallerand & Pelletier, 1993).

The separate scales were aggregated to assess the degree to which participants were autonomy-oriented, and control-oriented in line with SDT literature (Deci & Ryan, 2000; Ryan & Deci, 2000): Autonomy orientation is associated with intrinsic motivation and well-integrated (or identified) extrinsic motivation; corresponding AMS scales are IMTK, IMTA, IMES, and EMID. Control orientation is associated with introjected regulation and external regulation, which corresponds with the EMER and EMIN subscales respectively. Finally, amotivation measured by the AMOT subscale corresponds to an impersonal orientation. By calculating a Relative Autonomy Index (Black & Deci, 2000; Chen & Jang, 2010; Ryan & Deci, 2010), the scores on all individual subscales can be transformed into a single number, that, after performing a median split, allowed to discern between autonomy-oriented students (high RAI) and control-oriented students (low RAI). Previous research in a similar context using asynchronous discussion only showed learners scoring high on autonomy (high RAI) to contribute more to the overall discourse (quantity), but also to contribute more task-related messages (quality) (see Rienties, Giesbers et al., 2012).

3. Results

A first investigation of the 1742 codeable messages that were posted to the discussion forums showed large differences between individual contributions (χ^2 (41) = 92.36, $p < .001$). The values of the standard deviation, skewness and kurtosis per content analysis category further illustrated this large variation in discourse activities and showed contributions followed a non-normal (right-hand tailed) distribution (see Table 1). As an indication of the extent of knowledge construction activities (quality of contributions), we made a distinction between task-related (TR) and non-task-related (NTR) messages. On average, more task related messages than non-task related messages were posted (Table 1). What stands out with respect to the individual coding categories is the relatively low average of posts on the categories ‘social’ (cat.3) and ‘evaluation’ (cat. 9) which had also been found in previous studies in this voluntary online course context using asynchronous discussion forums only (Rienties et al., 2009).

Table 1. Contributions to discourse in total, and divided per category

	M	*SD*	*Skewness*	*Kurtosis*	*χ² (df)*
Non-task related	5.83	6.81	2.45	8.87	96.55 (19)
Planning (Cat. 1)	1.05	2.10	3.36	13.49	301.55 (8)
Technical (Cat. 2)	1.17	1.77	2.38	6.67	204.18 (8)
Social (Cat. 3)	.87	1.79	3.56	15.17	315.29 (8)
Nonsense (Cat. 4)	2.74	2.89	1.73	3.39	128.26 (13)
Task-related	9.81	12.52	2.15	6.66	206.20 (32)
Facts (Cat. 5)	2.20	4.64	4.24	25.65	446.95 (13)
Experience (Cat. 6)	1.85	2.47	1.71	2.58	183.8 (10)
Theoretical Ideas (Cat. 7)	1.81	3.19	3.20	13.20	269.20 (11)
Explication (Cat. 8)	3.66	4.67	1.55	1.73	190.76 (17)
Evaluation (Cat. 9)	.27	.73	3.16	10.33	281.09 (4)
Total	15.83	17.77	1.55	2.18	92.36 (41)

Total N = 110, all p < .001

Tables 2 and 3 present the Spearman correlation coefficients for the variables in this study and show a positive association between autonomy orientation and posting in the first three course periods which is in line with our expectations. Correlations of the individual AMS subscales suggest this is mainly due to the intrinsic motivation to know (IMTK) and to accomplish (IMTA). Similarly, a positive relation was found between autonomy orientation and taking part in the third and fourth web-videoconferences, which again seems mainly due to the positive association of the individual subscales IMTK and IMTA. Furthermore, there was a strong correlation between participation in the consecutive periods of asynchronous discussion and the consecutive web-videoconferences, except that the latter showed a low correlation between participation in the first and second web-videoconference. Participation in synchronous and asynchronous communication was highly related, except for the correlation between participation in the first web-videoconference and all consecutive periods of asynchronous discussion. Finally, positive associations were found between the final test grade and the consecutive instances of synchronous and asynchronous communication, where participating in the latter showed the strongest relation.

Table 2. Spearman intercorrelations between the variables in the research model (part 1)

	M	*SD*	IMTK	IMTA	IMES	EMID	EMIN	EMER	AMOT	AUT	CON
Synchronous communication											
Participation in VC1	.70	.46	0.14	0.10	0.06	0.13	0.03	0.08	-0.15	0.15	0.02
Participation in VC2	.50	.50	0.17	0.27**	-0.01	0.08	0.15	0.14	-0.06	0.16	0.15
Participation in VC3	.40	.49	0.24*	0.24*	0.15	-0.01	0.04	0.03	0.03	0.22*	0.03
Participation in VC4	.38	.49	0.22*	0.28**	0.20*	0.05	-0.02	-0.02	-0.03	0.23*	-0.3
Asynchronous communication											
Posts Period 1	10.62	10.13	0.39**	0.41**	0.20*	0.12	-0.04	0.12	-0.13	0.38**	0.04
Posts Period 2	6.36	7.33	0.21*	0.31**	0.07	0.19	0.01	0.21*	-0.12	0.25**	0.10
Posts Period 3	5.53	4.84	0.28*	0.31**	0.16	0.10	-0.02	0.12	-0.09	0.29**	0.03
Posts Period 4	2.54	2.52	0.21*	0.22*	0.08	0.1	-0.08	0.00	-0.04	0.19	-0.08
Performance											
Final exam grade	7.50	1.19	.19*	0.26**	0.09	-0.01	-0.02	0.03	0.04	0.18	-0.02

N = 110; * p < 0.05; ** p < 0.01

IMTK = Intrinsic Motivation to Know; IMTA = Intrinsic Motivation to Accomplish; IMES = Intrinsic Motivation to Experience Stimulation;

EMID = Extrinsic Motivation Identified Regulation; EMIN = Extrinsic Motivation Introjected regulation; EMER = Extrinsic Motivation External Regulation

AMOT = Amotivation

AUT = Autonomy oriented; CON = Control oriented

Table 3. Spearman intercorrelations between the variables in the research model (part 2).

	M	*SD*	VC1	VC2	VC3	VC4	Posts1	Posts2	Posts3	Posts4	Final test grade
Synchronous communication											
Participation in VC1	.70	.46	-								
Participation in VC2	.50	.50	0.18	-							
Participation in VC3	.40	.49	0.25**	0.41**	-						
Participation in VC4	.38	.49	0.23**	0.41**	0.50**	-					
Asynchronous communication											
Posts Period 1	10.62	10.13	0.16	0.43**	0.42**	0.36**	-				
Posts Period 2	6.36	7.33	0.04	0.32**	0.42**	0.38**	0.41**	-			
Posts Period 3	5.53	4.84	0.14	0.32**	0.35**	0.46**	0.52**	0.63**	-		
Posts Period 4	2.54	2.52	0.13	0.28**	0.37**	0.42**	0.31**	0.40**	0.31**	-	
Performance											
Final exam grade	7.50	1.19	0.19*	0.46**	0.64**	0.61**	0.60**	0.59**	0.69**	0.63**	-

N = 110; * p < 0.05; ** p < 0.01
IMTK = Intrinsic Motivation to Know; IMTA = Intrinsic Motivation to Accomplish; IMES = Intrinsic Motivation to Experience Stimulation;
EMID = Extrinsic Motivation Identified Regulation; EMIN = Extrinsic Motivation Introjected regulation; EMER = Extrinsic Motivation External Regulation
AMOT = Amotivation
AUT = Autonomy oriented; CON = Control oriented

3.1 Asynchronous Communication and Motivation

A distinction between autonomy and control-oriented students was made through a median split on the RAI score. A two-tailed Mann-Whitney U-test showed that autonomy-oriented participants posted more messages in total ($U = 1220$, $z = -1.74$, $p < .1$, $r = -0.17$) and also more TR messages ($U = 1234.5$, $z = -1.66$, $p < .1$, $r = -0.16$) than control-oriented students, although both differences were only marginally significant. There were no significant differences in the number of NTR messages.

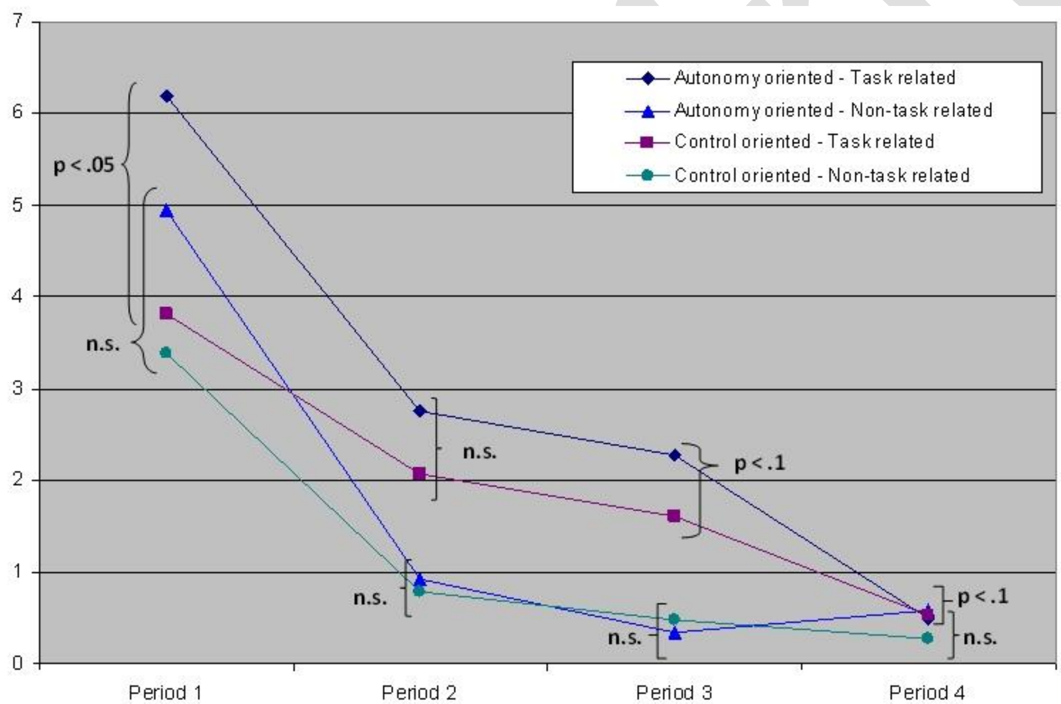

Figure 2. Average contributions for autonomy and control-oriented students for each course period.

Figure 2 shows the average contributions to discourse over the four course periods for autonomy and control-oriented participants. In general, after the first course period, activity in the discussion forums rapidly dropped. The second and third period show some decrease though far less steep, after which a steeper drop follows in the fourth period. When comparing the total number of posts per course period, only in the first period a (marginally) significant difference was found between autonomy and control-oriented students (U = 1210, z = -1.80, $p < .1$, r = -0.17). With respect to quality, a mixed picture emerged: In the first course period, a significantly higher amount of TR messages was posted by autonomy-oriented students (U = 1180, z = -2.00, $p < .05$, r = -0.19), but the difference on NTR messages was not significant. Differences between both TR and NTR messages posted by autonomy and control-oriented students in the second period were not significant. During the third period, autonomy-oriented participants posted slightly more TR messages (U = 1250.5, z = -1.76, $p < .1$, r = -0.17), and again differences on NTR messages were non-significant. Finally, during the fourth period, autonomy-oriented participants posted slightly more NTR messages (U = 1266.5, z = -1.81, $p < .1$, r = -0.17), and differences between the number of TR messages were non-significant. Figure 3 visualises the findings by depicting the correlations between autonomy motivation, TR and NTR posts.

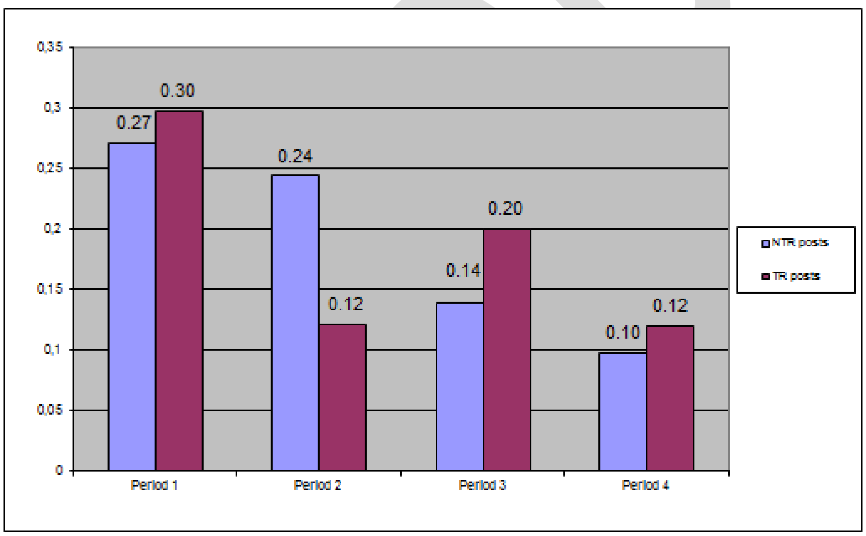

Figure 3. Correlations between autonomy motivation, TR and NTR posts per course period

In sum, although there were indications that autonomy-oriented students engaged more in asynchronous communication both in terms of quantity and quality (H1a), there is mixed support for this hypothesis. The same is true for H1b as differences in quantity and quality of forum posts were not associated with higher levels of autonomous motivation in each separate course period. Autonomous motivation seemed to primarily have an effect at the beginning of the course, but this effect seemed to wear off in subsequent periods.

3.2 Including Synchronous Communication

In each course period, a distinction was made between participants and non-participants attending the web-videoconference during that period. Table 4 contains the descriptives and Mann-Whitney U-test statistics for the total number of messages, and for TR and NTR messages posted by autonomy and control-oriented participants per period.

As can be seen in Table 4, for total and TR postings, students who took part in the web-videoconferences posted more on average than those who did not, which is true for both autonomy and control-oriented students separately, with the exception of the first course period for autonomy-oriented students. These findings largely support our expectations that participation in a web-videoconference is associated with higher engagement in the asynchronous forums, both in terms of quantity and quality (H2a).

Interestingly, when looking at participants in the web-videoconferences only, a Mann-Whitney U-test showed none of the differences between autonomy and control-oriented students in total or TR postings to be significant. The same was found for autonomy and control-oriented students who did not participate in a web-videoconference. Thus, the support for H2b, H2c, and H3 is inconclusive as differences between the motivational orientations could not be confirmed: participants and non-participants posted alike regardless of their motivational orientation.

			Web-videoconference participation						Mann-Whitney U-test			
			Yes			*No*						
			n	*M*	*SD*	*n*	*M*	*SD*	*U*	*z*	*p*	*r*
Autonomy oriented												
			37			16						
	Period 1	Total		11.86	12.08		9.69	12.05			n.s.	
		NTR		5.35	6.80		4.00	5.92			n.s.	
		TR		6.41	6.35		5.69	7.04			n.s.	
			27			26						
	Period 2	Total		6.67	9.44		0.81	1.65	146.0	-3.86	.000	-0.53
		NTR		1.37	2.02		0.46	1.17	255.5	-2.05	.040	-0.28
		TR		5.11	8.99		0.31	0.68	163.5	-3.74	.000	-0.51
			27			26						
	Period 3	Total		4.11	4.12		1.15	2.92	157.0	-3.68	.000	-0.51
		NTR		0.30	0.72		0.38	1.3			n.s.	
		TR		3.78	3.99		0.73	1.71	154.0	-3.77	.000	-0.52
			24			29						
	Period 4	Total		1.95	2.91		0.38	1.05	149.5	-3.95	.000	-0.54
		NTR		0.96	1.16		0.28	0.65	200.0	-3.07	.002	-0.42
		TR		0.96	2.05		0.10	0.56	232.0	-3.04	.002	-0.42
Control oriented												
			40			17						
	Period 1	Total		8.70	7.94		3.94	5.40	185.0	-2.71	.007	-0.36
		NTR		4.03	3.40		1.88	2.89	178.5	-2.86	.004	-0.38
		TR		4.58	4.79		2.06	3.17	214.5	-2.23	.025	-0.30
			28			29						
	Period 2	Total		4.03	5.36		1.90	4.09	233.5	-2.92	.004	-0.39
		NTR		1.14	1.84		0.44	1.02			n.s.	
		TR		2.71	3.49		1.44	3.22	245.0	-2.74	.006	-0.36
			17			40						
	Period 3	Total		4.24	6.83		1.18	2.61	240.0	-2.05	.041	-0.27
		NTR		0.88	0.76		0.30	1.96			n.s.	
		TR		3.35	5.34		0.88	1.98	228.5	-2.36	.018	-0.31
			18			39						
	Period 4	Total		2.06	2.51		0.23	0.54	176.5	-3.64	.000	-0.48
		NTR		0.67	0.77		0.10	0.31	205.5	-3.42	.001	-0.45
		TR		1.39	2.40		0.13	0.47	219.5	-3.28	.001	-0.43

Mann-Whitney U-test results include *U*-statistic, *z*-values, *p*-levels, and effect size (*r*)
N = 110 for every period

Table 4. Mann-Whitney U-test (two-tailed) results comparing average postings of web-videoconference participants and non-participants for each motivational orientation and course period separately

3.3 An Integrated Dynamic Path Model

A path model was calculated to obtain insights into the complex relations between the study variables over time, relating motivational orientation, participation in the synchronous web-videoconferences, and postings in the asynchronous discussion forums. Because the number of students who completed the final exam was 45.5% of this study's population, including this variable would lead to a sample size that is too small for path modelling (Anderson and Gerbing (1988) postulate a minimal sample size between 100 and 150), this variable is not included in the path model and relations with other variables are calculated using regression analysis. As the main focus of this study is on the relation between the actual use of synchronous and asynchronous communication, and motivation, we feel this choice to be legitimate.

Because we aimed to make visible any influence of the three motivational orientations, these were included based on their corresponding AMS subscales (i.e. IMTK, IMTA, IMES, and EMID for autonomy orientation; EMER and EMIN for control orientation, and AMOT for amotivation) and not the weighed RAI score. Using LISREL 8.8, several models were calculated, with and without making a distinction in the quality of postings (TR and NTR). Because differences in quality were shown to be inconclusive in previous analyses, and to obtain a model that best allows us to illustrate the transition over time between synchronous and asynchronous communication, total posts per period were favoured over making the distinction in quality. The dynamic nature of the model is that of a growth-model, so time-lagged relationships provide the specification of the several paths: synchronous communication intensity is hypothesized to depend on the level of intensity in the previous videoconference, and asynchronous communication intensity in the period in between the two videoconferences, whereas the number of postings is hypothesized to depend on the number of posts in the previous period, and activity in the previous videoconference.

The fit indices provided by LISREL show the resulting model adequately fits the data (χ^2 (40)=34.75 (n.s.), SRMR = 0.069, RMSEA = 0.000, 90% CI RMSEA = [0.000 – 0.047], NFI = 0.93, NNFI = 1.00, CFI = 1.00). Figure 4 depicts the path model with standardized estimates (beta's) of the relations between the model factors through time. Non-significant relations are depicted by a dashed arrow, all other relations are significant at $p < .05$.

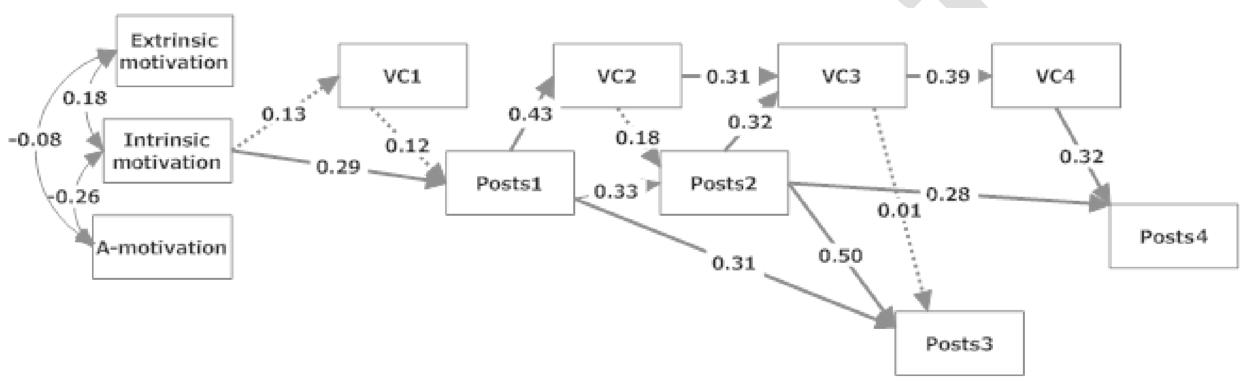

Figure 4. Path model (N=110) with standardised Beta scores depicting the relations between study variables

The main conclusion to be read from the path diagram was that the impact of motivation on synchronous and asynchronous communication intensity was solely through autonomous (intrinsic) orientation. Neither control (external) orientation nor amotivation did have any impact on videoconference participation in any period, or posts to the forum in any period. Interestingly, autonomous motivation was shown to be the only motivational variable with predictive value for engagement in asynchronous communication only, and only for the first course period.

Furthermore, the direct impact of autonomous orientation was limited to the first period, with a strong, positive impact on asynchronous communication, and a somewhat weaker, positive impact on synchronous communication. In later periods, any direct impact of motivation was suppressed by an indirect impact through communication intensity in the previous period. The absence of a direct path from autonomous orientation to communication intensities in later periods was in line with our earlier observations of a steadily decreasing role of the motivational variables. Instead, activity in the preceding period acted as the main predictor from period 2 onwards.

The path across the four separate course periods in Figure 4 (thus reading from left to right) was strongest via asynchronous communication, which makes sense as the core of the knowledge construction took place there. Engagement in asynchronous discussion in the second course period is strongly related to engagement in asynchronous discussion in the subsequent two periods, especially between the second and the third ($B = 0.50$). Furthermore, the influence of engagement in asynchronous discussion on participation in the subsequent web-videoconference (in the next course period) was relatively strong, with beta's ranging from 0.32 to 0.43.

The expected mutual influence of synchronous and asynchronous communication appeared to be most strong in the paths from asynchronous to synchronous communication, with all paths being significant at $p < .05$ and of moderate size. Paths in the reverse direction were somewhat weaker, except for the last period. The positive beta's indicate a mutual influence of engagement in synchronous and asynchronous communication, however stronger in one direction and not all are significant.

A multiple regression analysis was performed including only the students who completed the final exam. This choice was made to avoid a confound from the high number of students that did not complete the final exam and may have or have not been active in the synchronous and/or asynchronous communication. No significant effect of the motivation nor communication variables on the final exam score was found except for the number of posts made in the third course period ($R^2 = .20$, $B(SE) = .07$ $(.02)$, $\beta = .45$, $F\ (1, 49) = 11.90$, $p < .01$). This gives some indication that persistence in activity during the course leads to better results. A summary of the main findings is presented in Table 5.

Table 5. A summary of the results per hypothesis

Hypothesis	Independent variable(s)		Dependent variable	Dynamics	Expectation	Outcome
H1a	Motivation		Quality and quantity of asynchronous communication	All course periods	Positive association with higher levels of autonomous motivation	Mixed support: indications that autonomy-oriented students engaged more in asynchronous communication both in terms of quantity and quality. The path model confirmed this direct relationship for the first period of the course.
H1b	Motivation		Quality and quantity of asynchronous communication	Per course period	Positive association with higher levels of autonomous motivation	Mixed support: Autonomous motivation seemed to primarily have an effect at the beginning of the course, but this effect seemed to wear off in subsequent periods. This was supported by the path model.
H2a		participation in synchronous web-videoconferences	Quality and quantity of asynchronous communication	Per course period	Positive association	Supported: students who took part in the web-videoconferences posted more , and more TR messages on average than those who did not.
H2b	Motivation	participation in synchronous web-videoconferences	Quality and quantity of asynchronous communication	All course periods	Positive association, both for autonomy and control oriented motivation.	Mixed support: taken separately, both autonomy and control-oriented students who took part in the web-videoconferences posted more on average and more TR messages than those who did not, but with marginal significance.
H2c	Motivation	participation in synchronous web-videoconferences	Quality and quantity of asynchronous communication	Per course period	Positive association, both for autonomy and control oriented motivation.	Inconclusive: after the first course period, participants and non-participants in synchronous communication posted alike regardless of their motivational orientation. The path model supported the direct effect of autonomy oriented motivation in the first period, which became indirect in subsequent periods.
H3	Motivation	participation in synchronous web-videoconferences	Quality and quantity of asynchronous communication	All course periods and Per course period	Positive association,highest for autonomy oriented motivation.	Inconclusive: after the first course period, participants and non-participants in synchronous communication posted alike regardless of their motivational orientation. The path model supported the direct effect of autonomy oriented motivation in the first period, which became indirect in subsequent periods.

4. Discussion

This study explored the dynamic interrelations between synchronous and asynchronous communication in online learning, including the impact of motivation. We expected to find a positive relation between participation in synchronous communication on engagement in asynchronous communication (H2a), for both autonomy and control-oriented students (H2b), over all course periods (H2c), but stronger for autonomy-oriented students (H3). Our results showed that engagement in synchronous communication indeed positively affected engagement in asynchronous communication, with participants who did engage in video-conferences posting more, and more task-related messages in all periods than participants who did not, both for autonomy (with the exception of the first period) and control-oriented students. Moreover, the findings that: a) participants in a web-videoconference on the whole contributed more to the asynchronous discussions both in quality and quantity, b) autonomy and control-oriented students who participate in the web-videoconference post alike, and c) the influence of autonomous motivation was found to be limited in the path model, further point toward a positive influence of synchronous communication, as control-oriented students seem to be as much engaged into collaborative knowledge construction as autonomy-oriented students. However, the path model showed that the effect of asynchronous communication on synchronous was stronger than the reverse relation.

Based on previous research (Rienties et al., 2009; Rienties, Giesbers, et al., 2012), we expected that engagement in asynchronous communication both in terms of quality and quantity would be positively associated with higher levels of autonomous motivation (H1a) in each course period (H1b). Our results could not unambiguously confirm these expectations; both the non-parametric tests as well as the integrated path model revealed a mixed picture. Offering an integrated perspective over time, a path model showed only autonomous motivation to moderately explain the use of the discussion forums but only for the first course period. This is remarkable, since previous findings in a similar setting - but using only asynchronous communication - (Rienties et al., 2009; Rienties, Giesbers, et al., 2012) did show a strong (continued) effect of motivation on posting behaviour.

Reasons to help explain our findings most likely are different from demographic background of the population, and drop-out rates, as these were similar to previous years of the course (Giesbers et al., in press). Our findings regarding the fact that the influence of motivation was limited to the first course period fits findings from previous research where intrinsic motivation has been found to be high at the beginning of a course but to decrease later on (Guay et al., 2008; Guay, Vallerand, & Blanchard, 2000).

An alternative explanation could for example be that offering synchronous communication afforded control-oriented learners to be equally engaged in knowledge construction as autonomy-oriented learners. What may have also influenced our results is the extent to which the use of combined communication modes provided support for the tasks or learning activities at hand. Hrastinski et al. (2010) argued synchronous communication to have an intermediate to strong effect as task-support, but in their studies no distinction was made between different kinds of tasks, or in motivational profiles of the learners. It may be that there are certain learning tasks that are better supported by (a combination of) synchronous or asynchronous communication, and that the combination of tasks and communication mode influences student motivation.

Furthermore, Järvelä, Volet, and Järvenoja (2010) and Guay et al. (2008) suggested that motivation may very well be influenced by peers and therefore can also be seen as a dynamic result of group interaction compared to a more static individual characteristic. As such, participating in a web-videoconference, which enlarges the interpersonal dynamics, may have provided opportunities for students to mutually influence each other's motivation to engage in learning.

Future research should therefore include the role of tasks or learning activities, social factors, and collaborative construction of motivation when combining asynchronous and synchronous communication in online learning. This leads to three recommendations for further research: First, a dynamic analysis of motivation (i.e. via repeated measurement) is needed to identify changes over time. Second, in order to validate whether changes are influenced by task attributes or social factors, repeated motivational measurements should be combined with an analysis of synchronous discourse. The latter can, for example, be done in the form of content analysis of transcribed synchronous communication. Third, using social network analysis in combination with content analysis has been found to be a powerful tool to help understand group behaviour in online learning situations (De Laat, Lally, Lipponen, & Simons, 2007; Rienties et al., 2009). Using this method would allow to gain further insight in the effect of combined communication modes on the development of group relations over time.

A potential limitation of this study is the fact that the course was facultative and students could choose to be active or not. This, for example, may explain the finding that the influence of asynchronous communication on synchronous communication was stronger than the reverse. On the one hand, our context provided a unique opportunity to study the interrelation of variables in an authentic environment, but at the same time it may have influenced our results and may limit their generalizability to obliged courses. However, freedom of participation applies to many online course settings, where students voluntarily join for a variety of reasons (Bernard et al., 2004; Marks, Sibley, & Arbaugh, 2005). A high drop-out rate also is a characteristic of facultative courses where retention rates have been found to differ from 20-60% (Park & Choi, 2009; Rovai, 2003), in which our course is no exception. Apparently, the use of synchronous communication did not forestall the large drop-out rate. We therefore feel it is useful to conclude this study with a number of practical implications derived from our experiences that may help to improve online education based on a combination of synchronous and asynchronous communication.

4.1 Practical Implications

The path model indicated that autonomous motivation only had an impact at the start of the course, and the results presented in Table 4 showed that for autonomy-oriented students, it did not matter for the quantity and quality of posts whether they did or did not attend the videoconference in period 1. This suggests that at the start of an online course, efforts to enhance students' engagement in synchronous communication would mainly benefit control-oriented learners, but after the first course period, the motivational profile does not have a significant impact and autonomy-oriented students may benefit just as much from active encouragement to continue to attend the videoconferences and actively engage in the discussion forums. As we found a positive mutual influence between the two communication modes, it is interesting to find ways that stimulate engagement in both.

Group decisions to use asynchronous online communication have been found to depend on three aspects (So, 2009) that we feel could also apply to the use of synchronous communication. The first is a successful experience during the first trial of online communication. During the course, this has been explicitly supported by active tutoring in both synchronous and asynchronous communication. The second and third aspects are students' perceived affordances of the communication tools, and the interplay between the perceived efficiency and the nature of the collaborative tasks. It may be that engagement in synchronous communication may increase by emphasising these two aspects more explicitly.

Offering one web-videoconference per week for the first four weeks may have been too little, as many students engage in work or holiday activities during the summer period. In addition, offering synchronous meetings also decreases the freedom of time and place as students need to have access to a computer with internet at a certain time. These issues can be remedied by offering two or more per week, and allow students to choose when to participate, thereby increasing the flexibility of the course.

A more direct way to keep students actively involved is for example by scripting (i.e., a structured description on how to work on a specific task and/or how to collaborate with each other; Weinberger, Reiserer, Ertl, Fischer, & Mandl, 2005) or by assigning roles (Strijbos & De Laat, 2009). Face-to-face PBL settings usually assign roles like, for instance, discussion leader and scribe (Loyens et al., 2011) that are aligned with the function to give direction the discussion and to create a backlog of what is discussed. Wise, Padmanabhan, & Saghafian (2010) provide usable examples of how to implement roles based on functions. For example, assigning the roles of elaborator (who has the task to expand ideas that are brought into the discussion), questioner (who has the task to stimulate others to go deeper and elaborate on their contributions) and devil's advocate (who has the task to take a contrary position to ideas that are brought in and find arguments in support of their position) can be used to stimulate responses. A concrete and unambiguous description of the roles is necessary to support students in taking a certain role and avoid confusion (Wise et al., 2010). Assigning a concrete task in the form of a script or a role may on the one hand limit autonomy, but on the other hand, it may actually provide more structure and support for autonomy, helping students to shape their own learning process.

A final remark regarding future developments we would like to make, is that possibilities on the use of artificial intelligence (AI) to support teachers moderating discussions have advanced considerably. For example, McLaren, Scheuer, and Mikšátko (2010) reported initial positive results of an AI-based system (ARGUNAUT) that helps teachers identify key contributions and patterns when moderating multiple asynchronous group discussions. Further developments in this area are very promising, as this type of functionality enables teachers to focus autonomy support and structure more appropriately and timely, either through asynchronous or synchronous communication, in order to support student self-regulation and enhance student activity.

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Appendix A. Content Analysis Model of Veerman & Veldhuis-Diermanse

	Message		**Example in Economics**
	Not Task-Related		
Cat 1	*- Planning*		"Shall we first complete Task 1, before we go on with the next one?"
Cat 2	*- Technical*		"Does anybody know how to add a graph to my thread?"
Cat 3	*- Social*		"Good summary!"
Cat 4	*- Nonsense*		"Who wants to join us for a drink in the pub?"
	Task-Related		
	- New Idea		
Cat 5		*Facts*	"The average rate of inflation in the U.S. for 2004 is 2.7 %."
Cat 6		*Experience / Opinion*	"I think that VAT-taxes should be reduced to increase demand."
Cat 7		*Theoretical Ideas*	"According to Perloff (2003), consumers maximize utility subject to a budget constraint."
Cat 8	*- Explicitation*		"Moreover, this process necessitates that MR = MC."
Cat 9	*- Evaluation*		"Overall, combining the concept of utility and welfare, social welfare is maximized when every individual can sets MR = MC, without distortions."

Note: This table is based on Veerman and Veldhuis-Diermanse (2001), p.626. The examples in Economics are extracts from the discussion boards of the online course. For a more detailed description of the application of the content analysis in this context, see Rienties et al. (2009).