Original article

The impact of intrinsic motivation on e-learning in authentic computer tasks

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Abstract Students with high intrinsic motivation often outperform students with low intrinsic motivation. However, little is known about the processes that lead to these differences. In education based on simulations or authentic electronic learning environments, this lack of insight is even more clear. The present study investigated what students actually did in an electronic learning environment that was designed as a game-like realistic simulation in which students had to play the role of a junior consultant. The results show that students with high intrinsic motivation did not do more, rather they tended to do different things. Analysis of log files showed that the increased curiosity that students with high intrinsic motivation have, resulted in proportionally more explorative study behaviour. However, the learning outcomes of students with high intrinsic motivation were not better.

Keywords computer-based instruction, constructivist learning, motivation

Introduction

Simons *et al*. (2000) state that 'new' instructional methods ('new learning') have emerged, with concepts such as independent learning, active learning, self-directed learning, problem-based education, simulations, and work-based learning. Most of these methods are based on constructivism in which, according to Reiser (2001), learners become responsible for regulating their own learning process. Self-regulated learners are motivated, independent, and metacognitively active participants in their own learning (e.g., Duffy *et al*. 1993; Wolters 1998; Dalgarno 1998; Pierce & Jones 1998; Bastiaens & Martens 2000; Herrington & Oliver 2000). All these instructional models or methods hold that it is crucial to generate the learner's motivation. For this reason, many of the computer-based learning environments constructed present realistic problems, for instance through a simulation or a game. According to Garris *et al*. (2002) and Ellinger (2004), researchers are increasingly trying to link instructional strategies, motivational processes and learning outcomes. However, the research evidence is still 'embryonic', according to Garris *et al*. (2002, p. 442).

This article presents a model for motivation in e-learning. It describes how motivation influences e-learning behaviour, which in turn influences learning outcomes.

Ryan and Deci (2000) distinguish between extrinsic motivation, which refers to the performance of an activity in order to attain some separable outcome, and intrinsic motivation, which refers to doing an activity for the inherent satisfaction of the activity itself. The effort or motivation on which constructivist e-learning environments try to rely is typically intrinsic motivation, with its associated features such as curiosity, deep level learning (aimed at understanding, not at learning by heart, Marton & Säljö 1984), explorative behaviour, and self-regulation. Indeed, research has shown that intrinsically motivated students show more behaviour that can be described as explorative, self-regulated, aimed at deep level processing, and aimed

Accepted: 14 July 2004
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at exploration and reflection (e.g., Ryan & Deci 2000; Boekaerts & Minnaert 2003).

Ryan and Deci developed a model to explain and predict the persistence of intrinsic motivation. The basic assumption described by Ryan and Deci (2000, p. 70) is as follows: '. . . our theory of motivation does not concern what causes intrinsic motivation (which we see as an evolved propensity; Ryan *et al.* 1997); rather it examines what conditions sustain versus subdue and diminish, this innate propensity.' This approach can be linked to evolutionary psychology and can be found in, e.g. Bjorklund & Bering (2002) and Bjorklund & Pellegrini (2002). If humans become amotivated, there is a 'reason' for this in their perceived social and physical environment. This is a shift from the viewpoint common among developers that it is the developer who has to make the material motivating (e.g. the ARCS Model of Motivation, Keller & Suzuki 1988). Instead, developers should wonder what in the environment can make it 'amotivating'. In spite of the theoretical difference of both views on motivation, in practice, advice and guidelines derived from both viewpoints partly overlap.

The Cognitive Evaluation Theory (CET) of Ryan and Deci (2000) predicts that the perception of certain aspects of the social and task environment are crucial: a sense of relatedness, control or competence predicts intrinsic motivation. CET describes stages in motivation, varying from amotivation to intrinsic motivation, so intrinsic and extrinsic are not separate categories. There is quite a body of research evidence underpinning this model.

For the sense or *perception of control* positive correlations with intrinsic motivation are reported by Enzle and Anderson (1993), Pelletier *et al*. (2002), Nichols (2004), and Hardre and Reeve (2003). For educational software, this effect is reported by Kinzie *et al*. (1988) and Cordova and Lepper (1996). External rewards can lower the sense of control and lead to lower intrinsic motivation (Deci *et al*. 1999), although the exact influence of external rewards is not fully understood (Lepper *et al*. 1999). Iyengar and Lepper (2000) found that it is also possible to give too much choice or control, leading to negative motivational effects.

The effect of *perceived competence* has also often been demonstrated (Boggiano *et al*. 1988; Henderlong & Lepper 2002). In confirming competence, praise is positive for intrinsic motivation. But praise can become control by creating excessive pressure to continue performing well, which discourages risk taking and reducing the perception of autonomy (Henderlong & Lepper 2002). Mastery praise appears to be better than social comparisons (Henderlong *et al*. 2004).

Finally, the effect of a *sense of relatedness* (belongingness or connectedness with others) has been demonstrated quite often (e.g. Ryan & Deci 2000; Furrer & Skinner 2003, for an overview). Student's sense of belonging has a strong impact on intrinsic motivation.

The effects of intrinsic motivation on student learning have often been studied. Cordova and Lepper (1996) tried to increase intrinsic motivation via educational software. As predicted, learners exposed to motivationally embellished activities had higher levels of intrinsic motivation. As a result, they became more deeply involved in the activities, attempting to use more complex operations, and thereby learned more from the activities in a fixed period of time. Intrinsically motivated students are more persistent and more likely to achieve set goals (Curry *et al*. 1990), with a much smaller drop-out risk in education (Vallerand, Fortier & Guay, 1997; Hardre & Reeve, 2003), with more self-regulation (Pintrich & de Groot 1990) and higher self-reported well-being (Levesque *et al*. 2004) with less avoidance behaviour (Thompson 2004). Overviews (e.g. Ryan & Deci 2000) indicate that intrinsically motivated students are more curious, and engage more in deep level learning, which holds true for students of all age groups (cf. Turner *et al*. 1998; Wolters & Pintrich 1998; Bruinsma 2003). However, more extrinsically motivated students do not simply always do less than their intrinsically motivated counterparts (Ryan & Deci 2000). In other words, we need to know more about how motivation leads to cognition. This is, according to Pintrich (2003), one of the leading questions to be answered by the 'motivational science'.

The problem is that most studies about the effects of intrinsic motivation are based on indirect measures, such as student's self-ratings, assessed via questionnaires. It is also unclear what correlates with intrinsic motivation and what causes intrinsic motivation or results from intrinsic motivation. Most studies look at effects but neglect the process by which motivational orientation interacts with the actual study behaviour (Hakkarainen *et al*. 1999). The relation between intrinsic motivation and persistence or study results is only confirmed by looking at outcomes such as results of exams or drop-out rates (e.g. Pintrich & de Groot 1990; Vallerand *et al*. 1997). The *process* via which intrinsic motivation influences these dependent measures is much less understood. What do intrinsically motivated students actually *do* differently when compared with their less intrinsically motivated counterparts?

Looking at e-learning, this lack of insight is even more plain. E-learning can be seen as a form of independent learning. Independent learning has long lacked process research (Martens 1998). We do not know what students actually do with the learning materials provided to them (e.g. Martens & Valcke 1995; Martens *et al*. 1996). Song and Keller (2001) note that in contrast with the high expectancies that developers have of 'motivating' constructivist e-learning, little is known about the actual impact of this increased intrinsic motivation on the study process (e.g. Kinzie *et al*. 1988; Cordova & Lepper 1996; Amory *et al*. 1999; Keller 1999; Garris *et al*. 2002). Besides, it is questionable whether developers actually manage to increase motivation with the programs they develop. Simply adding multimedial add-ons is not enough to increase motivation and developers of educational software often have misconceptions about the motivational impact of their programmes (Honebein *et al*. 1993; Garris *et al*. 2002; Martens *et al*. 2002). There are indications that distance learners are at greater risk of losing intrinsic motivation because their sense of relatedness is lower (Rovai & Lucking 2003).

To increase the understanding of the relation between e-learning and motivational processes, it is necessary to gain a better understanding of learning materials that are developed to increase motivation. Garris *et al*. (2002) state that educationalists are increasingly trying to use hard-to-define specific features of games to enhance learning. This attempt is not difficult to understand: all over the world games attract millions of players who are very motivated, self-regulated, and persistent in playing these games. It is not easy to define a game, just as it is not easy to define the difference between a game and a simulation or an authentic learning environment (such as a virtual company). According to Garris *et al*. (2002), a game can best be described as 'an activity that is voluntary and enjoyable, separate from the real world, uncertain, unproductive, and governed by rules' (p. 442). This definition of a game shows that games, simulations, and authentic learning environments cannot be sharply distinguished from each other. Simulations, games or authentic learning programmes often have in common that they try to present a 'realistic' context, in which a student has to play a role. Even if the context or the problem is completely imaginary, it still has to be convincing, challenging, and 'realistic'. This article is not about the exact difference between these types. In this article we focus on common features often found in simulations, games and authentic learning programmes and describe all these various applications as Authentic Learning Programmes (ALPs).

Two constituents of the definition of games and thus of ALPs appear crucial. Firstly, it is important that players have the perception that 'it is a game, that is not for real', allowing them for instance to take risks and engage in experiments. The second important feature is that game playing is a voluntary activity. This highlights a problem that many ALPs have: education is very often not based on voluntary activities. Because educational games are mostly compulsory, it may be difficult for students to perceive these instructional games as 'fun' (cf. Garris *et al*.). Game playing has a strong resemblance with intrinsically motivated behaviour. In both cases the perception of 'fun' is crucial and too much external control is detrimental.

Garris *et al*. developed a input-process-outcome instructional game model. In the centre of this model is the game cycle: a continuous process of game-playing activities in which user judgments influence user behaviour that influences system feedback, which influences user judgments. The input for this process is the instructional content and the game characteristics, and the outcome of this cyclic process is defined by the learning outcomes.

This article is restricted to the study of what happens in the game cycle in the centre of the model described above. More specifically, it examines how intrinsic motivation relates to user behaviour in e-learning. The aim is to increase our understanding of the process differences between intrinsically motivated and less motivated students. In order to analyse the impact of intrinsic motivation on the process, insight into the actual students' study activities is required with as little interference with this behaviour as possible. Instead of focusing on very informative but interfering and hard-to-quantify qualitative methods like think aloud protocols or interviews, this study aims at the direct measurement of study behaviour. Analysis of log files enables the straightforward assessment of quantitative and qualitative differences in study behaviour between the two types of participants. In line with the motivation theory of Ryan and Deci (2000), it is predicted that both these differences will occur. So, intrinsically motivated students will do *more* in a fixed time period as a result of their higher effort and persistence (possibly resulting in more factual knowledge) and will do *different* things in computer environments that allow for this liberty of choice (explore proportionally more parts of the program that are designed to gratify participants' curiosity). Both hypotheses will be tested 1-tailed by means of (partial) correlations. Students' self-ratings about their motivation and explorative behaviour will be compared with the data obtained from log files, to check whether these two are connected.

In line with Kinzie *et al*. (1988), student vs. programme control over the task will be used as an intervening variable. As stated above, the control dimension might be crucial in educational software. The aim is not to manipulate the perception of relatedness or competence.

Method

Participants

Subjects were 33 higher education students, 16 students studying psychology at the University of Maastricht and 17 students studying technology at the Institute of Higher Education in Heerlen in the Netherlands. All participants were approximately 20-years-old with roughly equal numbers of men and women. The participants were randomly assigned to one of the two experimental conditions.

Materials and procedure

The ALP that was used in this study was called *Buiten Dienst* (*Out Of Service*). This is an authentic programme implemented in an electronic learning environment with a lot of multimedia. The ALP simulates a consultancy firm that is given the assignment to write a report about why there is so much absence through illness in a bus company. The student is placed in the role of a junior consultant and has to analyse this problem directed by three steps. There were two important reasons for developing this ALP: the ALP *Buiten Dienst* is much more efficient in aiding students to acquire important skills. Students do not actually have to go to real companies, get to know people, find their way, and so on. Moreover the problem and the context are scaffolded. What in a real company (during a work placement) would take weeks of work now can be simulated in some days or even hours. Secondly, the fact that it is only a simulation of a real company makes it more likely that students dare to take risks and to make mistakes, which can be helpful for the learning process. As indicated in the introduction, students' awareness that 'it is only a game' is an important aspect of ALPs.

For practical time reasons, in this experiment we used a part of the ALP, which originally consisted of 16 steps. The part of the ALP used consisted of three phases: first, an interview with the functionaries of the bus company, second work floor research, and third a reflection report. It was tested beforehand to ensure that within about three hours students were able to place themselves in the role of junior consultant and acquire sufficient information from the ALP to write a reflection report. Besides collecting information through following the three steps, students had other possibilities to collect information about the bus company. They could, for example, 'talk' to a senior advisor or a secretary, read articles in their archive or read e-mails on their personal computer. Students were free to look for these other options, but the three steps were given to them as steppingstone. In the *learner control condition* it is completely up to the student how to move through the ALP, while in the *program control condition*, separate guidelines on paper determined *the order* of how students were to go through the ALP. Apart from these additional written guidelines, the ALP, all the tests and the task were exactly the same in both conditions.

After students finished working with the ALP (maximum allowed working time was 3 h), their performances were measured with a multiple-choice test consisting of seven questions concerning the content of the programme, focusing on factual knowledge about the content (Cronbach's $\alpha = 0.57$). Such tests are very often used at, for instance, the Open University. A second effect measurement was based on the reflection reports: the quality of the reports was judged based on the number of correct content statements that they contained, controlling for the total number of words that students used to write the report. The content statements were based on the relevant content information available in the ALP for solving the problem. Examples of content statements were 'bus drivers experience a high workload' and 'the manager is completely unsympathetic'. The reports were scored by two independent raters with and inter-rater reliability of 0.95.

Intrinsic motivation was measured with a 5-point scale consisting of 6 items (example of item: 'Learning in this environment is fun'; Cronbach's $\alpha = 0.81$; $n = 33$). Measuring intrinsic motivation with 5- or 7-point scales has often been done and many researchers report high validity and reliability (e.g. Ryan *et al*. 1990; Boekaerts & Minnaert 2003). Items were partly copied, translated into Dutch and adapted to the specific test situation. The six-item scale that measured the self-reported tendency towards explorative behaviour in the environment (e.g. 'This environment incites explorative learning'; Cronbach's Alpha = .92; $n = 33$) was newly developed.

The programme *Watch* allowed accurate and reliable track analysis. Due to the specific design of the learning environment, each action on the computer (mouse click) was represented by a new page in the loggings that *Watch* automatically created. This made it possible to count the total number of 'pages' or items that students visited in the electronic learning environment. Furthermore, the learning environment was sorted according to pages that were explorative and pages that were not explorative. Explorative pages were defined as pages that students were not explicitly directed to by external sources. The three steps mentioned in the previous section (interview, work floor research and report) defined the pages that were not explorative, because these steps explicitly stimulated students to visit certain pages. For example, if students (electronically) interviewed the manager of the bus company, they were not exploring, but if students looked for information in the archive of the consultancy firm, they were. By using this definition, the explorative pages in the programme could be designated, which made it possible to count the number of explorative pages a student visited. The explorative pages that were counted were visits to the senior advisor or to the secretary, and the number of pages that were read in the archive or in emails. About a quarter of the pages that could be visited by the participants was labelled as explorative. Participants were not aware of these labels. The variable *proportion exploration* was calculated by dividing the number of explorative pages a participant had visited by the total number of pages that this participant had visited. This variable was an indicator of the tendency towards explorative behaviour, corrected for the total number of pages visited. A high score on *proportion exploration* means that this participant has a relatively high tendency towards explorative behaviour.

Results

The data were checked for violations of assumptions underlying parametric analyses (e.g. KS test for normal distribution). The log file of one participant with extreme scores turned out to be unreliable due to technical problems and was excluded from further analyses. Table 1 presents the descriptives for the samples.

In Table 2 the scores on all the dependent measurements, displayed by condition, are shown.

MANOVA showed no significant impact of condition (task control) on the dependent variables (Table 2). A separate univariate analysis of the key variable confirmed this: ANOVA showed no significant impact of condition on intrinsic motivation. Therefore in the forthcoming analyses both conditions are analysed jointly. Intrinsic motivation does not correlate significantly (tested 1-tailed) with the number of pages visited ($R = -0.09$). Nor do the number of pages visited and the proportion of explorative pages visited correlate significantly ($R = -0.15$). However, intrinsic motivation and the proportion explorative pages visited correlate significantly ($R = 0.34$, $P < .05$, one-tailed): more intrinsically motivated participants are relatively more explorative.

From these data it can be concluded that intrinsically motivated students do not do more (processing more parts of the ALP), but rather they do qualitatively different things. Participants with high intrinsic motivation are more explorative. To substantiate the statistical significance of this finding,

Table 1. Descriptive statistics for complete sample

	n	Minimum	Maximum	Mean	Standard deviation
Intrinsic motivation (1–5)	32	1.80	4.40	3.27	0.716
MC test factual knowledge (0–1)	33	0.25	0.75	0.43	0.12
Number of content statements in reflection report	31	4	22	14	4.4
Self-reported explorative behaviour (1–5)	32	1.33	5.00	3.70	0.82
number of pages	32	191	622	357.72	105.32
number of explorative pages	32	25	172	70.28	41.49
Proportion exploration (0–1)	32	0.07	0.48	0.20	0.10

Table 2. Dependent variables per condition

Condition	Mean	Standard deviation	Valid *n*
Learner control			
Intrinsic motivation	3.22	0.72	17
MC posttest	0.42	0.08	17
Content statements	14. 2	3.5	16
Number of explorative pages	75	42	17
Number of pages	386	91	17
Proportion exploration	0.1972	0.0948	17
Program control			
Intrinsic motivation	3.32	0.73	15
MC posttest	0.48	0.14	15
Content statements	13.4	5.4	15
Number of explorative pages	65	42	15
Number of pages	326	114	15
Proportion exploration	0.2049	0.1175	15

instead of correcting for the number of files via computing the variable proportion exploration, the partial correlation between the absolute number of explorative pages visited and intrinsic motivation can also be computed, controlling for the total number of files. This partial correlation is $R = 0.314$ ($P < 0.05$, one-tailed). The correlation between intrinsic motivation and measured explorative study behaviour is confirmed by students' self-reported inclination to explore the environment ($R = 0.69$; $P < .0001$, 1-tailed). This means that intrinsically motivated students report more explorative behaviour. Finally, the multiple-choice post-test and the number of content statements in the reflection report did not correlate with intrinsic motivation.

Discussion

This study investigated what students actually do in an electronic learning environment, in order to gain a better understanding of the problem stated by Garris *et al*. (2002): 'Intuitively we would assume that greater effort, engagement, and persistence would lead to a more positive learning outcome, yet there are clearly instances (such as when the effort is directed to activities that are not congruent with instructional objectives) in which this is not the case.' (p. 460). In this study, it was found that students with high intrinsic motivation do not tend to work harder in the same amount of fixed time, rather they tend to do different things. Analysis of log files shows that the increased curiosity that students with high intrinsic motivation have results in proportionally significantly more explorative study behaviour. However, the performance measures (MC-test and content statements) showed that students with high intrinsic motivation did not acquire more knowledge of the content.

Although research evidence is available that describes how intrinsic motivation is related to students' perceptions of task and social factors, much less is known about the process of how this intrinsic motivation leads to better study results. CET (Ryan & Deci 2000) predicts that high intrinsic motivation is correlated positively with curiosity and exploration. This prediction is corroborated by research findings from, for instance, Cordova and Lepper (1996), Curry *et al*. (1990) and Vallerand *et al*. (1997). Furthermore, a recent study based on questionnaires for university students by Bruinsma (2003) showed that there is a relation between motivation and deep level learning or understanding. However, Bruinsma did not find any relation between this deep level learning and study outcomes. Bruinsma suggests that this is caused by the assessment methods generally employed at universities. There is too much focus on facts. In other words, students' curiosity is not rewarded by the system. This might also have been the case in the multiple-choice test of factual knowledge we used in this experiment. This test also had no significant correlation with intrinsic motivation. The same may account for the absence of a correlation between intrinsic motivation and the number of content statements in the reflection report. Although this is a measure for the quality of the report, it is possible that the reflection reports still focuses mostly on factual knowledge, thereby not 'rewarding' the explorative behaviour either.

This study has provided more insight into the game cycle that is at the heart of the input-process-outcome instructional game model of Garris *et al*. by giving more information about the qualitative differences in study behaviour that are related to intrinsic motivation. This study confirms the results of studies (Ryan & Deci 2000, for an overview) that show a positive relation between intrinsic motivation and curiosity. We commented on these studies that they are usually based on students' self-reports, but this study de facto showed that such self-reports are quite valid, for a clear connection was found between self-reports and students' actual behaviour as measured by computer loggings.

Some critical remarks about this study have to be made. First of all, the number of subjects was restricted, decreasing the power of the tests used and increasing the chance of a type 2 error. Nevertheless, a significant difference was found. Second, the time on task was restricted. If students had had the opportunity to work longer, the explorative behaviour of the intrinsically motivated students might have proven to be more successful. It is conceivable that explorative behaviour and deep level learning is a disadvantage when tasks or problems have to be studied in a relatively amount of time and thus more superficially. However, the study time that was available for the participants was based on standard study estimates used at the Open University of the Netherlands and resembles daily reality of students, since in reality study time is also restricted. This study shows what students do in a fixed time period; it does not show what the effects of the increased persistence of intrinsically motivated students might have been over a less fixed time period. It is to be expected that drop-out rates are negatively correlated with intrinsic motivation. A common practice in evaluating e-learning in higher education is that the assessment procedure is not aligned with the learning behaviour the ALP aims at. In this study we deliberately chose a multiple-choice test as one of the performance measures, because this is one of the most common kind of summative assessment that is used in higher education (Sluijsmans & Martens 2004). It demonstrates that this kind of assessment is not suitable for measuring new kinds of learning. Moreover, the other performance measure used in this study (content statements in the reflection report) was meant to be a more appropriate measure of students understanding, because this evaluated whether students could use the content they learned in the report they had to write as a consultant. Unfortunately, this turned out to be an inappropriate measure for rewarding understanding as well.

The design guidelines derived from this research have to be formulated in a rather negative way. Ideally, simulations and problems presented via computers are so rich that explorative behaviour is indeed rewarded. Quite often, however, developers tend to add multimedial add-ons, simulations, and so on, mainly because technology makes it possible (cf. Garris *et al*. 2002), even though they are not based on careful educational analysis and design (van Merriënboer & Martens 2002). Such an instructional intervention is to be advised against. If the multimedial add-ons and real-life simulations do not contribute to a better understanding, this research suggests that this is not only a waste of developers' time and energy but also unfavourable for the 'best' students. It is questionable if these add-ons make students more intrinsically motivated and in any case, students with the highest intrinsic motivation scores will be the most likely to study these add-ons, which is useless if this explorative behaviour is not 'rewarded' by the used performance measure. On the other hand, if ALPs do lead to more explorative learning behaviour and this is a desired outcome, then new assessment forms have to be developed that are in line with this 'new learning' approach (Sluijsmans & Martens 2004).

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