Chapter 6
Narration-Based Techniques to Facilitate Game-Based Learning

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Abstract In this chapter, we discuss the role of narration-based techniques like curiosity-triggering events and surprises that are included in games in learning and motivation. We focus on the learning of proportional reasoning, an important component of mathematical skills, with secondary prevocational students (12–15 year). Based on the information gap theory of Loewenstein and the cognitive conflict notion of Berlyne we argue that curiosity-triggering events and surprises can have a positive effect on learning. Inserting these events in the game *Zeldenrust* did indeed show positive learning effects, though the size of effect depends on the preexisting (meta)cognitive abilities of the students.

Keywords Serious games • Mathematics • Curiosity • Surprise • Learning • Motivation

6.1 Introduction

The question raised in this chapter is how we can stimulate players to engage in relevant cognitive processes that foster learning without jeopardizing the motivational appeal of the game by making use of narration-based techniques. From film and story understanding literature it is well known that stories can have an engaging influence on readers (Brewer & Lichtenstein, 1982). Stories also facilitate understanding and memory of the sequence of events that are part of the event structure that forms the basis of a story (Kintsch, 1980). Less clear from the same literature are the effects of certain techniques or directed manipulations of story structures that maximize the effects on emotion and learning. One exception here is the influence of techniques such as curiosity and surprise (Brewer & Lichtenstein, 1982; Hoeken & van Vliet, 2000; Kintsch, 1980). By starting a story with its outcome, readers become curious about how this event came about, leading to more attention

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for the story. Surprise is evoked by an unexpected event. It can be created by inserting in a story an event that does not follow the normal flow of events nor is directly compatible with it. It stimulates the reader to wonder why this event happened, leading to enhanced and focused cognitive processing (Kim, 1999).

Also on the domain of serious games the role of stories and strong story lines in Game-Based Learning (GBL) is emphasized (Barab, Gresalvi, & Ingram-Goble, 2010; Dickey, 2006, 2011), though empirical support is still scarce (Adams, Mayer, MacNamara, Koenig, & Wainess, 2012; Pilegard & Mayer, 2016). Also the role of curiosity and surprise is neglected, though they represent on the domain serious games in our opinion promising techniques. To start with curiosity, it can be regarded as a motivator for active cognitive explorative behavior (cf. Berlyne, 1960; Litman, 2005; Loewenstein, 1994) and active exploration is a key aspect of contemporary computer games (Dickey, 2011). Next, surprise is generally conceived as a disruption of an active expectation. The situation described does not correspond to expectations of the reader (or player). Common to curiosity and surprise is that they both involve the experience of a cognitive discrepancy or conflict in the mental representation that the player is building up. That is, a cognitive conflict in the sense that events are introduced that can only be understood after extra cognitive processing which is needed to make the mental representation after all still coherent (Maguire, Maguire, & Keane, 2011).

In this chapter, we will first elaborate the concept of cognitive conflict and information gap that readers or players experience with surprises and curiosity-triggering events. Next we will present own work on the role of curiosity with regard to learning in serious games, and after that, discuss own work on the role of surprise in serious games. In our work on curiosity and surprise, we have followed a 'value-added' approach (Mayer 2011, 2016). In this research approach, we compare the learning outcomes of students who play a base version of a game (control group) with those who play the same game, but with one feature added, the curiosity or surprise-triggering events, respectively (treatment group). In the last section, we will draw conclusions and discuss implications.

6.2 Role of Curiosity and Surprise in Engaging Players in Game-Based Learning

In his review, Loewenstein (1994) proposes an information gap theory in which *curiosity* is supposed to arise when attention becomes focused on a gap in one's knowledge. Such an information gap produces the feeling of deprivation labeled curiosity. The curious individual is motivated to obtain the missing information in order to reduce the gap and to eliminate the feeling of deprivation.

This interpretation of an information gap is also related to Berlyne's concept of a cognitive conflict (Berlyne, 1960). This construct encompasses 'collative' variables such as complexity, novelty, and surprisingness. The presence of these stimulus characteristics (curiosity-triggering events) would arouse cognitive conflict and stimulate curiosity. In this case, an information gap occurs when stimuli, for instance, text fragments, present contradictory or incongruent information. For example, in the game a learner is told that a presented problem can be solved but the game environment appears to offer no opportunities to solve the problem. This interpretation of an information gap can also be regarded as a cognitive conflict, namely, the conflict in the current mental representation of the learner between (1) the expectations of the learner (e.g., expectations based on the assurance that the problem can be solved) opposed to (2) the affordances in the learning environment to solve the problem.

The assumption, in line with Jirout and Klahr (2012), is that this information gap will motivate students to explore the environment and find relevant information for constructing and applying appropriate solution methods. More specifically, we assume that based on Loewenstein's (1994) and Berlyne's (1960) ideas that externally inducing an information gap can stimulate curiosity, raise arousal, and consequently enhance explorations in the game environment and in this way improve learning.

In another context, using a puzzle game involving the ability to plan like solving the Tower of Hanoi problem, we have shown that omitting particular information on the display of a computer screen versus explicitly showing it did not affect the efficiency of the game adversely but did improve learning, especially of the underlying rules of the game (Van Nimwegen, 2008; Van Nimwegen, van Oostendorp, & Tabachneck-Schijf, 2005). We concluded that presenting visual support resulted in passive cognitive behavior. On the other hand, those who were refrained from this information and thus experienced an information gap were prompted to proactive and plan-based problem-solving behavior, leading to more effective cognitive processing. We assumed that creating an information gap by omitting relevant information in this study indeed would lead to a cognitive conflict that triggered effective exploratory behavior, and consequently to better learning.

A second promising technique in the generation of manageable cognitive conflicts consists of introducing *surprises*. We define surprise here as a disruption of an active expectation under influence of surprise-triggering events. Surprise also involves an emotional reaction and serves a cognitive goal as it directs attention to explain why the surprising event occurred and can play a key role in learning (Foster & Keane, 2015; Howard-Jones & Demetriou, 2009; Ranganath & Rainer, 2003).

The experience of surprise arises when an observed event causes a previous coherent representation to break down, resulting in an urgent representational updating process (Itti & Baldi, 2009; Maguire et al., 2011). Studies investigating the comprehension of narratives stress the idea that surprise is linked to ease of integration of the surprising event into the mental representation that is being built in Working Memory. Along the same lines, Kintsch (1980) also assumes that surprising events have important effects on the cognitive reading process. When reading a story, readers build a mental representation of it. The occurrence of a surprise triggering event forces readers to reassess their representation of the story up till that point, because a surprising event is by definition not a logical sequel to the preceding events. They have to check their representation to see whether they missed something. As a result of this reassessment and coherence checking, encoding and subsequently learning of the preceding events improves. On the domain of narratives and text comprehension it has been shown that surprise has a beneficial effect on learning. Hoeken and van Vliet (2000) found that surprise improved text comprehension and appreciation more than other techniques such as events that aroused curiosity and suspense. Likewise, O'Brien and Myers (1985) confronted participants with a word that was either predictable or unpredictable from a preceding context and observed that the texts that preceded unpredictable words were better recalled.

We assume that the effect of surprise may also pertain to problem solving or learning cognitive skills as mathematics in serious games. Ideally, mental models enable students to recognize specific characteristics of a problem and how to solve that problem. Because our aim is to integrate the instructional technique (i.e., the introduction of a curiosity-triggering event or surprise) with the learning content (Habgood & Ainsworth, 2011), the curiosity-triggering events and surprises have to be focused on what has to be learned, i.e., the mental model. For this reason, the curiosity-triggering events or surprising events change some of the problem characteristics and the solution method previously applied is no longer applicable and the player has to reevaluate the situation and decide which problem characteristics are relevant and also which solution method is now most appropriate. We expect thus that also surprise has a positive effect on learning because it may stimulate relevant cognitive processes such as organizing and integrating information (Mayer, 2011; Moreno & Mayer, 2007; see Fig. 1 in Chap. 1) without compromising the motivational appeal of computer games.

6.3 Role of Curiosity in Game-Based Learning

In this section, we will discuss some recent empirical work we performed on curiosity and learning mathematics, such as the skill of proportional reasoning. The goal of the studies discussed here was specifically to study the role of curiosity and we will detail the way we manipulated curiosity. As indicated earlier the advantage of curiosity induced by an information gap is that individuals are cognitively active in an engaging way. Scholars have emphasized the potential of curiosity in GBL (Dickey, 2011; Malone, 1981; Wouters, van Oostendorp, Boonekamp, & van der Spek, 2011) but empirical research is scarce. For instance, Wouters et al. (2011) showed empirically that introducing narrative elements as foreshadowing creates curiosity; however, it did not yield learning. The game for which we used the well-known game *Re-mission* (Beale, Kato, Marin-Bowling, Guthrie, & Cole, 2007) contained as foreshadowing technique briefly showing events in advance that occur later in the game. This foreshadowing technique can be regarded as an example of an information gap: some information is shown, but it is not sufficient to fully understand what is happening. Consequently, the attention of the players is drawn and they will be motivated to find the remaining information as soon as an opportunity arises. Compared to a control condition on a curiosity questionnaire the experimental condition showed higher curiosity. However on a (limited) factual recall test, there was no significant difference though the experimental condition showed somewhat better performance.

In next studies, the aim was to investigate more systematically whether the use of curiosity in a GBL environment enhances learning for proportional reasoning. Our operationalization of curiosity was based on Loewenstein's information gap theory (1994) as introduced earlier.

6.3.1 Game

The game involved proportional reasoning. This topic was chosen because it is a relevant and well-defined domain and existing methods for proportional reasoning are often ineffective (Rick, Bejan, Roche, & Weinberger, 2012). Several types of problems can be distinguished. For instance, in missing value problems one value in one of two proportions is missing and learners have to find this "missing value" in order to ensure that both proportions are equal (for a more extensive description see Vandercruysse et al., 2014, and Chap. 2 this volume). In the 2D game (Flash/Actionscript) called *Zeldenrust*, students have a summer job in a hotel (see http://www.projects.science.uu.nl/mathgame/zeldenrust/index.html for a demo). By doing different tasks the students can earn money that they can use to select a holiday destination during the game: the more money they earn, the further they can travel. During the game, the player is accompanied by the manager, a nonplaying character, who provides information about the task and gives feedback regarding the performance on the task. The game comprises a base game and several subgames. The base game provides the structure from which the subgames can be started that cover specific problem types in the domain of proportional reasoning. The tasks are directly related to proportional reasoning (e.g., mixing two drinks to make a cocktail according to a particular ratio directly involves proportional reasoning skills). In addition, mental operations with respect to proportional reasoning are connected with the game mechanics (e.g., in order to get the correct amount of bottles in the refrigerator the player has to drag the correct number of bottles in the refrigerator).

In the *control* condition, all assignments were presented in an identical way and all information required to perform the assignment was available. In the *curiosity* condition, the operationalization of curiosity involved two phases. First, the student was told that a strange situation had occurred but that the current problem could still be solved (Fig. 6.1a). In this way, we created an expectation in the student that was not immediately compatible with the situation in the game. Second, the student was confronted with a game environment in which it was not immediately clear how the assignment could be solved. Taken together, we regard this as a cognitive conflict, namely, the conflict between the expectations of the learner and the affordances in the learning environment. They have to explore the contents in the crates and decide how they can solve the problem the best. For example, the blackboard in Fig. 6.1b makes clear that four bottles of Cola have to be moved into the refrigerator; however, there are not directly available four bottles of Cola. The learner can hover

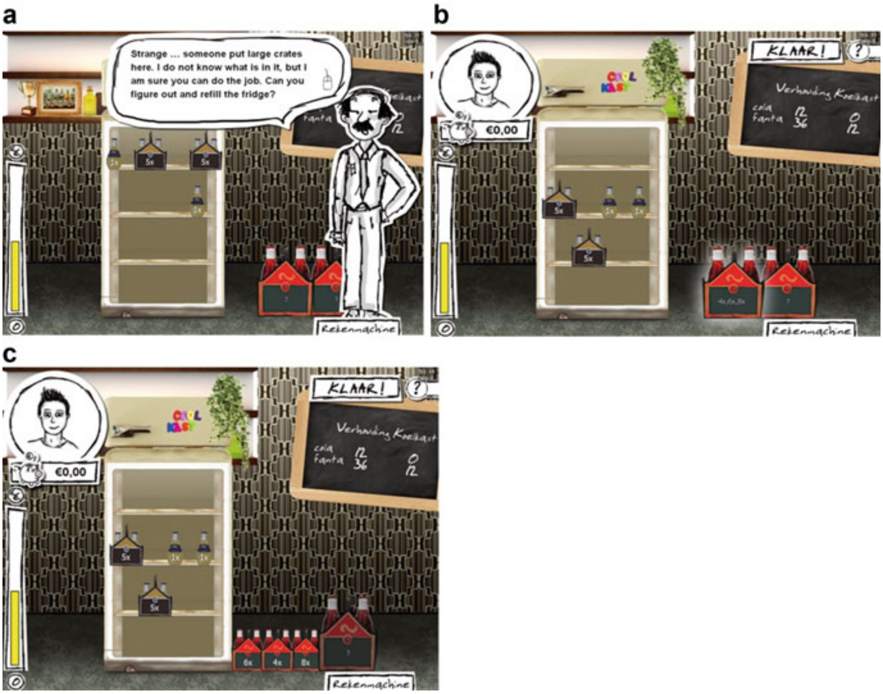

Fig. 6.1 The implementation of curiosity (**a**) depicts the initial situation, (**b**) shows the content when hovering over the crate with the mouse, and (**c**) shows the situation when the crate is unpacked

the crates to find out and reveal their content. The left crate in Fig. 6.1b contains three smaller packages with 4, 6, and 8 bottles. By exploring the different crates, the learner can decide which crate contains the packages that can best be used to solve the problem. With a mouse click the large crates are unpacked and the smaller packages become available, one of them with the right amount of bottles (Fig. 6.1c). Our assumption was that students had to explore the game environment and find and evaluate the objects (crates/bottles) that would enable them to implement the solution that they had conceived.

Before and after playing the game, a proportional reasoning skill test was administered in two groups of prevocational students. One group received the experimental version of the game (with the curiosity-triggering events) and the second group played the control version of the game (without these curiosity-triggering events).

6.3.2 Outcomes of Studies on Curiosity

The results of a first study with *Zeldenrust* showed that playing the game had a learning effect, that is, in both conditions there were significant gains in proportional reasoning skill; however, the curiosity condition did not advance more in proportional reasoning skill than the control group (Wouters et al., 2015a, 2015b). In a second study with improvements on instruction and interface design, game play did not yield learning, though in both studies performance on the game assignments contributed strongly to offline posttest performance (based upon multiple linear regression analyses). However, most important is that we in both experiments failed to find a beneficial effect of the curiosity-triggering events compared to a control condition that played the game without curiosity-triggering events embedded. The curiosity condition was not any better than the control condition.

As explained, based on Loewenstein's (1994) and Berlyne's (1960) ideas, we hoped that these *situational*, i.e., externally defined, determinants would induce curiosity. The game environment however had a strong repetitive character which made it perhaps difficult to maintain a curiosity effect. Our implementation of curiosity depended on a conflict or incongruity between what players was told and what they saw. Some remarks can be made regarding this implementation. Can an incongruity that is materialized in two different modalities (verbal and visual) evoke the intended cognitive conflict? It was maybe difficult for some students to make a connection between what was told in the verbal modality and what was shown in the visual modality. This may also explain the confusion that some students experienced when they were confronted with the curiosity-triggering events. It is worth to investigate the impact of the curiosity-triggering events when they occur in only one modality. We don't know exactly if players experienced a cognitive conflict or that they were just confused. For this reason, an obvious next step might be to understand what players think or experience when the curiosity-triggering events occur. Interesting methods in this respect are the use of think-aloud protocols and/or eye tracking.

In a third experiment using the same *Zeldenrust* game we manipulated the knowledge gap more directly by varying in the game the difficulty level of tasks compared to the current level of the player (De Wildt, 2015). The idea is that a higher difficulty level should make the knowledge gap larger. The basic idea of Loewenstein (1994) is that a difference between the current knowledge level and the knowledge needed to solve a particular problem may evoke curiosity and the desire to close the gap (when it is not too big or too small) which leads to extra attention and learning. Players were presented game tasks of a higher difficulty level (large knowledge gap) compared to the current skill level of the participant or—in the other condition—of the same difficulty level (small or no knowledge gap). We assume that a large knowledge gap leads to a clearer and more salient cognitive conflict than a small knowledge gap. So a situation representing a larger knowledge gap (bigger discrepancy in knowledge) makes the cognitive conflict more clear and more salient leading to a higher state of curiosity and an increase of learning.

We did indeed find a marginal significant positive effect of knowledge gap ($p < .08$) on learning as reflected by the performance on the proportional reasoning skill test. So introducing a knowledge gap can increase learning gain. We have the impression that the results can be enhanced further when more subtle measurements and adaptations of skill level are made. In the current study, we determined it beforehand and the study used only a small number (3) of difficulty levels. When adaptation occurs more smoothly and continuously, bigger positive effects may be expected, as for instance in the study of Van Oostendorp, van der Spek, and Linssen (2014). They showed a large positive effect of dynamic adaptation in terms of efficiency of players. The game used here was *Code Red*: *Triage*, a game focused on training a triage procedure for medical first responders. Compared to a control condition with no adaptation, an online, adaptive version of the game was (about 30 %) more efficient and lead to higher learning gains per instructional case.

Summarizing these studies to the role of curiosity, positive effects on learning can be found but the effects are subtle. They depend, for instance, on the clarity or saliency of the curiosity-triggering event and the knowledge level of the player.

6.4 The Role of Surprise in Game-Based Learning

In this section, we discuss studies in which we investigated the different dimensions of surprise in different games and domains.

Empirical research has demonstrated that indeed surprise can have specific effects on brain activity, also in a serious game context. Georgiadis, van Oostendorp, and van der Pal (2015) studied specific effects of surprise on brain activity as measured by EEG. In this study, a game was constructed in which the player acted as an undercover agent who had to perform a series of actions in order to save commercial supplies on an island from terrorists. Surprises consisted of inserting events that were unexpected compared to preceding events, like a sudden fire or explosion in a car. In a control version the surprises were left out. The results showed that surprises did lead to a more wakeful state indicated by lower Delta brainwaves (Hammond, 2006). Furthermore, experiencing surprises did lead to better in-game performance and better handling of later surprises by being more relaxed and conscious, as indicated by lower Alpha brainwaves (Benca et al., 1999), compared to a control version of the game without surprises. The last result indicates that training of surprises can have practical positive effects.

In the context of learning a medical procedure with a serious game called *Code Red*: *Triage*, Van der Spek, van Oostendorp, and Meyer (2013) demonstrated that surprise yielded superior knowledge structures, indicating that surprising events foster deep learning. They assumed that also in games players construct a mental model based on the story line, the events, and the underlying rules of the game. During understanding a story, readers construct a situation model in which dimensions such as the protagonist, time, space, causality, and intentionality are monitored and connected (Zwaan, Langston, & Graesser, 1995). When there are gaps constructing a connection takes more effort and time. Likewise, in computer games players construct a mental model and/or situation model based on the story line, the events, and the underlying rules of the game (Van der Spek et al., 2013). The situation or mental model makes new events plausible (although such events may cause adaptations in the model) and provides the starting point for expectations of the reader or player. A surprise, on the other hand, is unexpected and does not follow from the situation/mental model in a standard way. Readers/players will wonder what they have missed and start to reevaluate preceding events and infer events that make the surprising event understandable. In this process, the mental model will be activated, retrieved, and updated, thereby enhancing learning (Van der Spek, 2011; Van der Spek et al., 2013). As mentioned before we assume that this mechanism is also applicable to problem solving.

In two studies we investigated the impact of surprise on learning proportional reasoning and how this impact is moderated by the expectancy of the student (in the second study). We used the same GBL environment *Zeldenrust* as mentioned earlier.

In the first study, a group of prevocational students coming from different educational levels playing the game with surprises occurring during the game was compared with a group without these surprises (control group). We expected that the group with surprises would learn more than the control group.

6.4.1 Game

The control condition was the same as the control condition in the curiosity experiments. The *surprise* condition comprised a nonplaying niece character in the introduction animation telling that she sometimes will make it difficult to carry out the task. When the surprise occurred the niece character popped up and told that she had changed something. This change involved a sudden change of specific characteristics of the task whereby the solution method of the player doesn't apply anymore and the player has to reconsider the original solution method. The surprise is here thus a sudden change of some characteristics of a state in the situation. Figure 6.2 gives an example of the occurrence of a surprise. Figure 6.2a depicts the starting situation. The player can solve the problem by looking at the ratio "within": the number of Fanta in the refrigerator is twice as much as the number of Fanta in the desired proportion (12 Fanta) since $12 * 2 = 24$, so the number of Cola also has to be doubled ($9 * 2 = 18$ Cola). When the player is implementing the solution, the surprise occurs consisting of the nonplaying character suddenly changing the situation (Fig. 6.2b). When the niece character has disappeared the characteristics of the task are modified (Fig. 6.2c); that is, the desired proportion is now 5 Cola per 10 Fanta. The ratio "within" is not applicable anymore and the player can better use a method based on the ratio "between" (the desired proportion is 5 Cola/10 Fanta, so the number of Cola in the refrigerator should also be half the number of Fanta, 12/24). So the surprise does not simply concern some numbers. It also urges the player to suddenly change the solution method and replace that for a new one. In total the players received 8 surprises.

6.4.2 Outcomes of Studies on Surprise

The results of the first study indicated that surprise was beneficial for higher level students, while the main effect of surprise versus no surprise was not significant. For this reason, we repeated the study with only higher educational level students.

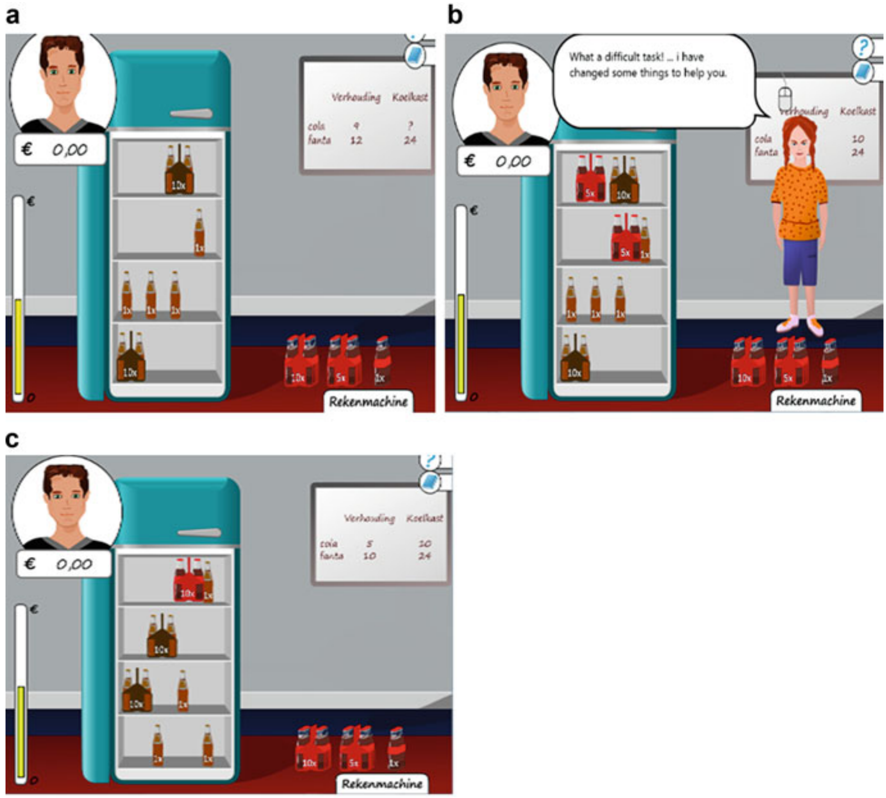

Fig. 6.2 (**a**) Starting situation in a task with a surprise, (**b**) notification of the surprising event, and (**c**) modification of task characteristics in the game *Zeldenrust*

We did find in this second study a significant positive effect of surprise on the posttest of reasoning skill when we included preexisting proportional reasoning skill as factor (Wouters et al. 2015a, 2015b).

Summarizing the results to the role of surprise shows that positive effects of surprise can be found, though the effect depends on the (meta)cognitive level of the students.

6.5 Conclusions

Overviewing the outcomes of our studies on curiosity and surprise with the game *Zeldenrust*, we can conclude that curiosity can have a moderate positive effect on learning; however, the effect depends on the clarity of the curiosity-triggering event and the knowledge level of the player. Surprise shows a positive effect but also here the effect depends on preexisting (meta)cognitive abilities of the student.

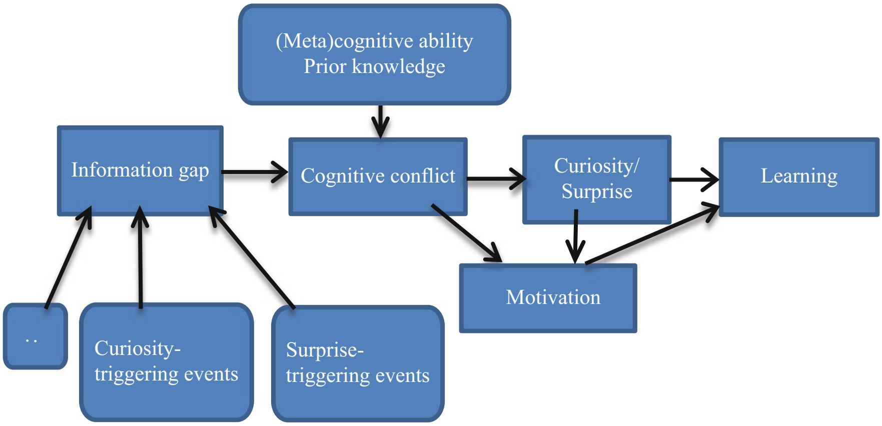

Fig. 6.3 Relation between narration-based techniques as curiosity and surprise-triggering events, and motivation and learning

When we compare the effects of curiosity-triggering events with the effects of surprises, it seems that we do find more easily positive learning effects of surprises while the effects of curiosity are weaker or not present at all. One reason could be that it is more difficult to trigger effectively curiosity with the inserted events; there is still much freedom for players to use them or not or to decide in what direction the inference processing in order to solve the problem should go. The surprises seem to be more constraining, and because of that, perhaps more effective. It is with a surprise immediately clear what the information gap is that has to be resolved, and thus what the cognitive conflict is. With a curiosity-triggering event, it depends on many factors (e.g., their saliency or clarity) whether the curiosity-triggering event leads to explore the information space in the right direction—and indeed to exploration at all—leading to a less well-defined information gap, and consequently, less clear cognitive conflict. See Fig. 6.3 in which we have depicted the assumed relationship between narration-based techniques like curiosity and surprise, and learning.

The results we found imply that instructional techniques such as curiosity and surprise should be applied with care. An important precondition for the occurrence of effective curiosity and surprise seems to be that players have sufficient cognitive flexibility and metacognitive abilities and prior knowledge to orientate on the task, to reevaluate the results at the moment when the surprise or curiosity-triggering event occurs and to reflect on the performed actions. See also Fig. 6.3. Students with sufficient (meta)cognitive abilities seem to be able to handle surprises and curiosity-triggering events in complex learning environments such as computer games, students who lack these competencies can be overwhelmed by the additional cognitive demands that are introduced by these techniques. However, more research to the relation between (meta)cognitive abilities, and curiosity and surprise is required to investigate the robustness of the surprise and curiosity effects and the underlying cognitive mechanisms.

We have discussed in Sect. 6.2, the role of curiosity and surprise in engaging players in game-based learning, and as indicated in Fig. 6.3 we assume that narrative techniques as including curiosity and surprise-triggering events can also have a positive influence on motivation, and because of that, also on learning. In our studies we focused on learning so we cannot confirm the indirect positive effect of curiosity and surprise on learning. Future studies should look into the role of motivation triggered by these techniques.

Curiosity and surprise require as indicated earlier cognitive flexibility and (meta) cognitive abilities because they imply a deviation from what students expect. Students who do not have an adequate level of cognitive flexibility and/or (meta) cognitive abilities may benefit from additional instructional support that will help them to understand the problem and possible solution methods. In this way, the consequences of curiosity and surprise for the problem may become clearer. In our own research on surprise, we expected students to select an appropriate method for a given problem type but we found that some students always used the same method regardless of the problem type. This attenuates the effect of surprise because the purpose of surprise—to consider another method when the problem type suddenly changes—is beyond their cognitive ability. To support these students, the surprise intervention can be preceded by exercises that will help them to select an appropriate method for a problem. One could think of exercises that help them to automatize part tasks such as multiplication tables so that they can more easily identify "intern" or "extern" ratios and/or worked examples in which strategies for specific types of problems are modeled.

Two other lines of research can be directly relevant to our research on narration-based techniques such as surprise and curiosity. The first one concerns the role of (meta)cognitive abilities. There is some evidence that metacognitive skills in mathematics improve with small differences in age (Van der Stel et al., 2010). The students in the second study on surprise had a mean age of 13.9 years (second year class) and the metacognitive skills of some may have been insufficiently developed. Another point is that the students come from the least advanced of three Dutch prevocational tracks in which students are prepared for intermediate vocational education. It would be interesting to replicate our studies on curiosity and surprise with older students in the same educational level (third or fourth year class) or students from a higher educational track.

A second research avenue pertains to the characteristics of the game. The game *Zeldenrust* we used as test bed to investigate the usefulness of narration-based techniques such as curiosity and surprise has unfortunately a repetitive character; that is, students engage in the same type of tasks which require similar actions. It is not unlikely that students finally will expect that, for instance, the surprising niece character will reappear and modify the nature of the task. In that case they may even anticipate these events and thus undermine the potential effect of surprise. The same applies to the curiosity manipulation. If that is the case more variation in surprise or curiosity can perhaps further increase their effectiveness.

It may seem that the introduction of curiosity or surprise adds more difficulty to the problems presented. Two comments to this suggestion can be made. First, making a problem in first instance somewhat—not too much because the gap should not be too large—e.g., by omitting particular information, can improve learning, particularly of the underlying rules of the problem (Van Nimwegen, van Oostendorp, & Tabachneck-Schijf, 2005). Second, we want to point out that our results showed surprise did have a positive effect on learning, particularly of students with sufficient (meta)cognitive abilities.

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