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ABSTRACT

Title of Document: **A Model of Contextual Factors and their Effects in the Interruptive Notification User Experience**

Celeste Lyn Paul, Ph.D., 2013

Directed By: Dr. Anita H. Komlodi, Department of Information Systems

Interruptive notifications in a desktop environment are an important service that knowledge workers rely on for maintaining awareness of information and services outside their current focus. Research to date has focused primarily on empirical laboratory-based testing, which is very specific and out of context of a realistic user environment, and broad ethnographic research, which is not specific enough for meaningful notification system design guidelines. This dissertation aims to address the gap between existing laboratory-based and ethnographic research by conducting a series of studies that explored the notification user experience in a both broad and deep way. The results of this research contribute the following: A catalog of significant contextual factors that affect the notification user experience; a series of models that describe how factors in the notification system context influence the overall user experience; a set of design guidelines, derived from this research but generalized to be applicable to any interruptive notification system.

A MODEL OF CONTEXTUAL FACTORS AND THEIR EFFECTS IN THE INTERRUPTIVE NOTIFICATION USER EXPERIENCE

By

Celeste Lyn Paul

Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, Baltimore County, in partial fulfillment
of the requirements for the degree of
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I would have written a shorter letter if I had the time.

– Blaise Pascal

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Science. It works.

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Chapter 1: Introduction

> "In an information-rich world, the wealth of information means a dearth of something else: a scarcity of whatever it is that information consumes. What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the overabundance of information sources that might consume it."
>
> – Herbert Simon, 1971 pp.40-41

Thanks to affordable personal computing devices and a ubiquitous Internet connection we are living in an increasingly active information environment. As this information environment becomes more active and rich, the demands on our attention also increase. Attention is a finite commodity we must carefully manage. There is a need for services that help us maintain awareness of new and updated information while managing the effects interruptions have on our attention. Interruptive notifications, such as alerts for a new email or a disconnected network, are examples of services that help us maintain awareness of changing information while allowing us to focus our attention on other tasks. The focus of this dissertation is on the automated pop-up interruptive notifications from various applications and services in the desktop computing environment with a focus on knowledge workers.

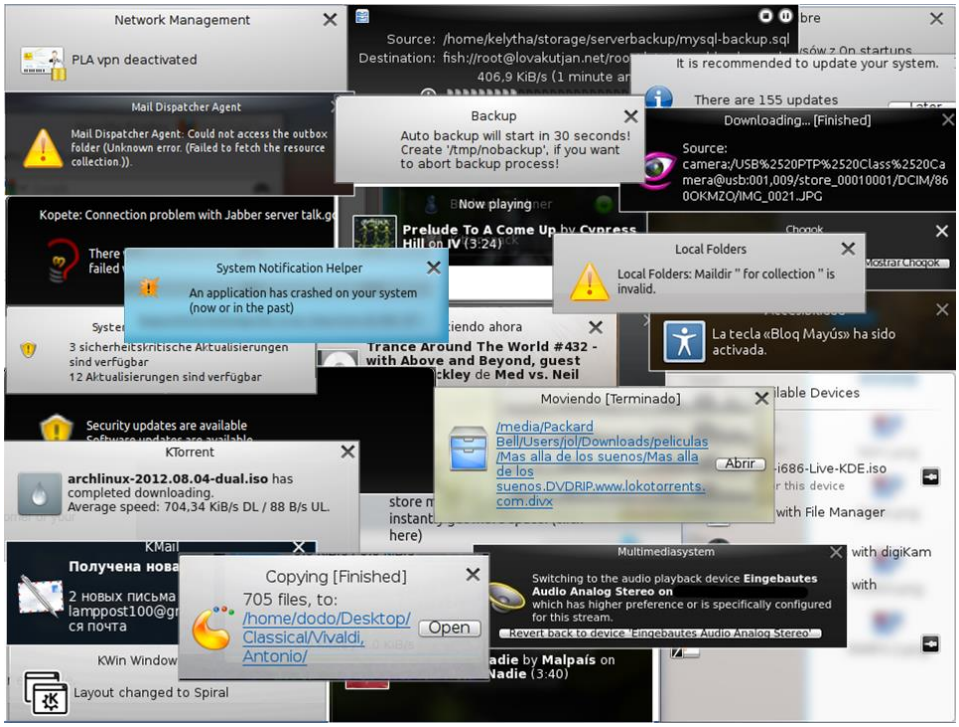

Figure 1: Examples of notifications experienced by desktop computer users

Interruption is the method of forcefully switching attention from one piece of information to another. *Notifications* are a type of information alerts that informs the user of an event or update. *Interruptive notifications* are notifications that draw the user's attention in order to inform him of the new event or information, such as a new chat message from a friend. The nature of these message displays is interruptive because the system must divert the user's attention in order to deliver the information. This type of notification is different from passive notifications that do not interrupt users in order to inform them, such as an email about a new comment on your blog waiting for you in the Inbox. Manually checking for new information is tedious and time consuming, and many events and services rely on interruptive notifications to deliver information updates to users in a timely manner.

While interruptive notifications serve an important role in an active information environment, they can also be a source of user distraction, annoyance, and dissatisfaction. The design of interruptive notifications presents a challenge because these services must deliver information to the user while balancing the costs of interrupting the user with the benefits of information awareness. As more of our information moves to online and distributed services that are dynamically and frequently updated, the importance of awareness of these updates and the need for better interruptive notification management increases. Although studying interruptions is a classic human factors topic, there is continuing interest in understanding interruptions in multitasking environments in the CHI community (Gould et al. 2012).

The goal of this dissertation research is to improve interruptive notification systems for knowledge workers on desktop computers by empirically studying the contextual factors of the notification user experience. In this dissertation, I studied a variety of knowledge workers who were involved in the KDE open source software project (described in Chapter 5: Methodology). While modern computing for casual users is moving towards a more ubiquitous and mobile platform, knowledge workers rely on desktop computers in order to do their jobs. The daily work of knowledge workers involves critical thinking, communicating with people, and using productivity applications that are only available and best suited for a desktop environment. Notifications are an important service that helps knowledge workers successfully manage their tasks. While the focus of my research was on people from the KDE community, the results are transferable to many other domains and settings where

knowledge workers accomplish their tasks using desktop systems. Notifications will continue to play an important role in assisting desktop users, with managing their services. Continuing to investigate the interruptive notification user is essential for supporting a future knowledge worker-friendly desktop environment. The notification models and desktop guidelines developed as part of my work (presented in Chapter 7: Discussion) have the potential to impact the work environment, usability of notifications, and the general user experience of desktop system for a large number of users in the future.

The results of my dissertation research are organized as follows. In Chapter 2: Related Work, I describe the related work in interruptions and notifications from the fields of Human Computer Interaction (HCI), design, and psychology. There, I frame the gaps in the current research that leads to the problem space my dissertation addresses. Next in Chapter 3: Statement of Research, I describe the problem space I attempt to address in my research and identify research questions designed to progressively fill in some of the gaps I identify in the interruption context-related literature. In Chapter 4: Exploratory Study, I describe the results of an exploratory study conducted to explore the interruptive notification user experience, including examples of contextual factors that affect the user experience and how interruption context might be studied in more detail. In Chapter 5: Methodology, I describe the research activities I conducted to address my research questions. In Chapter 6: Results, I report the results of each of my research activities. In Chapter 7: Discussion, I discuss the implications of my work. Finally in Chapter 8: Conclusion, I present my contributions to the HCI community and discuss potential future research.

Chapter 2: Related Work

Most of the HCI research in interruptions and notifications investigates the empirical effects of interruptions on the user during the task cycle and the usability of interruptive notification software. Little work has been done to understand the context of the interruption or notification, such as under what conditions a user would want to be interrupted. This review of the literature describes current work in interruptions and notifications from three perspectives.

First, I will describe foundational interruptions research in HCI and psychology to understand when to interrupt the user. Second, work that investigates interruptive software user interfaces such as notifications is described in order to understand how to interrupt users. Third, work related to understanding the user's context of use in interruptive systems is described in order to know why the user ought to be interrupted.

2.1 Interrupting Users

Knowing when to interrupt the user within a task cycle has been the focus of most interruption literature. Miyata and Norman's Theory of Interruption Costs (1986) is an important starting point. Their theory asserted that “interruptions where memory load is high will be disruptive, whereas interruptions where load is low should be less disruptive”, that is, the cost of interruption will be lower if the interruption occurs when mental load is lower and vice versa. *Cost of interruption* refers to the negative effects of the interruption, such as reduced task performance or reduced user

satisfaction. *Memory load* refers to the amount of information that can be stored in short-term (working) memory at any time.

In their work, Miyata and Norman identified the best and worst points for interrupting the user based on Norman's seven-stage User Activity Model (1988). The User Activity Model is defined by three phases containing seven stages of user mental activity:

1. **Planning phase**, includes the stage for formation of a task goal
2. **Execution phase**, includes the stages for formation of intention, specifying of an action, and execution of an action
3. **Evaluation phase**, includes the stages for perceiving of the state of the world, interpreting the state of the world, and evaluating the outcome

Miyata and Norman identified that the least interruptive point in a task (and therefore the best time to interrupt the user) is in the final stage of a task while the user is evaluating the outcome of his/her actions. However, the final stage is not the only time a user could be interrupted with minimum impact to the task. They also suggested that the user could also be interrupted between the Execution and Evaluation phases because the beginning of the Evaluation phase relies on external information, such as system status displayed on a screen that helps support user memory, therefore mental load should be lower. Miyata and Norman also warned that the worst point for interruption is during the Execution phase when the user is directly interacting with the system. Figure 2 summarizes Miyata and Norman's best and

worst points for interrupting the user's task based on their Theory of Interruption Cost in the context of Norman's User Activity Model.

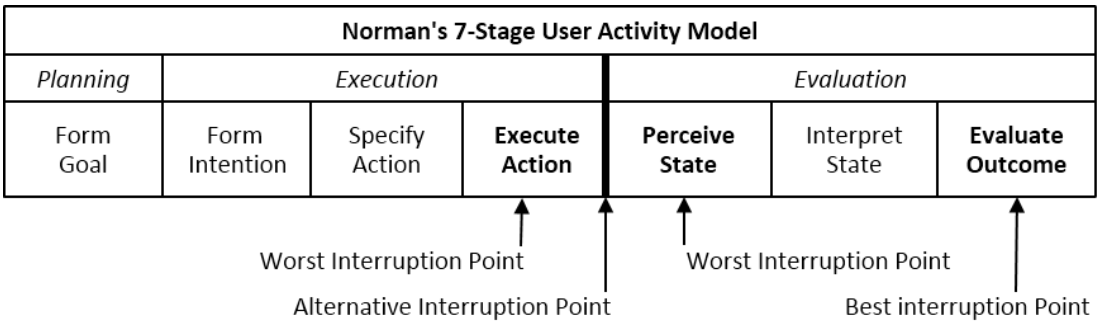

Figure 2: Miyata and Norman's interruption recommendations according to the Theory of Interruption Cost in the context of Norman's seven-stage User Activity Model

Subsequent work in interruptions uses Miyata and Normans Theory of Interruption costs and Norman's User Activity Model as a reference point for their own work. Figure 3 provides a summary of interruption literature applied to Norman's User Activity Model.

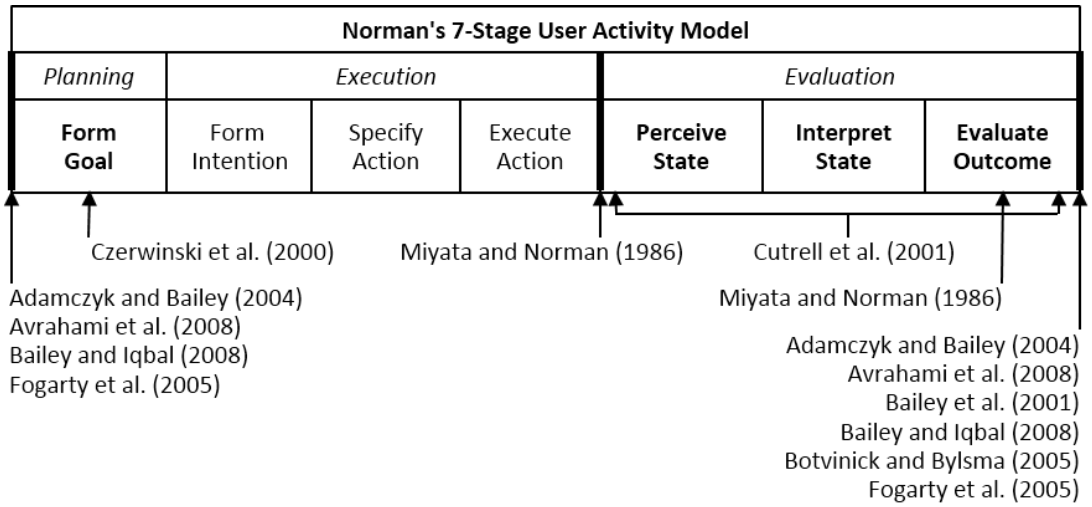

Figure 3: Summary of interruption literature applied to Norman's User Activity Model

2.1.1 Interruptions between Tasks

Most interruptions research has found that the best time to interrupt users is between the main tasks. Bailey et al. (2001) found that users presented with interruptions during the main task perceived the interruptions as more annoying and reported experiencing more anxiety than interruptions presented after a task. Users also perceived the main task less difficult if they were not interrupted during the task. Users also took longer to complete the main task if they were interrupted. Later work by Adamczyk and Bailey (2004) found that interruptions between well-defined tasks were perceived by users as less annoying, less frustrating, and they created less mental load and required less mental effort than interruptions during a task. A related study by Bailey and Iqbal (2008) showed that mental load decreases between subtasks, with a greater decrease of mental load between "larger chunks of the task". This link suggests that the difference in mental load during tasks with interruptions compared to tasks without interruptions is large enough for users to perceive a difference.

Other researchers have also found that the size of the group of tasks related to a goal affects how disruptive an interruption is, and that interrupting between smaller tasks has a greater effect on the main task than interrupting between larger "chunks" of tasks. Botvinick and Bylsma (2005) found that users committed fewer errors in the main task when interrupted at the end of a task than when interrupted during a task. Fogarty et al. (2005) found that the less time it took a user to attend to an interruptive task, the better the model they developed could predict an interruption point (described in more detail in 2.1.3 Methods of Interruption). They also found that the

most accurately predictable interruption points were when a user had recently switched between applications or completed an interaction.

Avrahami et al. (2008) found that users were faster to respond to interruptions during greater work-fragmentation, breaks in continuous work activity often characterized by longer mouse movements, and increased keyboard activity. Similar to Fogarty et al., they found that users were faster to respond to an interruption if they had recently switched between applications. These findings provide additional support for interrupting users between tasks and for avoiding interruption during tasks.

2.1.2 Interruptions during Tasks

Although most post-Miyata and Norman interruption research focuses on interruptions between sets of tasks, there is some work that continued to look when during a task a user could be interrupted. Czerwinski et al. (2000) found that users were faster to respond to an interruption at the beginning of a main task than at other task stages. Users were slower to respond to an interruption later in a main task. They suggested that the best time to interrupt the user is early in the task during the Planning phase, before the user becomes “deeply engaged” in completing the task.

However, Cutrell et al. (2001) found that users interrupted earlier in a trial were more likely to request task reminders than users who were interrupted later in a task. They suggested that interruptions earlier in a task are more disruptive than those later in a task during the Evaluation phase and recommended avoiding interruptions at the beginning of a new task. Considering that Miyata and Norman suggest interruptions are best between the Execution and Evaluation stages, this inconsistency suggests that

research should continue to focus on interruptions between tasks rather than trying to identify when to interrupt users during a task.

2.1.3 Methods of Interruption

Knowing that between tasks is the most optimal time to interrupt users presents a challenge in designing interruptive software. There are a number of ways the timing of interruptions could be controlled by the user or by computer software. Several researchers have investigated different methods for timing and presenting interruptions to users.

Gillie and Broadbent (1989) concluded from their studies that the ability for the user to control the timing of their response to an interruption was not the important factor in what made an interruption disruptive; however, there is a body of research that demonstrates that there are real differences between immediate interruptions, computer-negotiated interruptions, and user-controlled interruptions.

McFarlane (2002) directly compared different methods for interrupting a user during a task. In his study, four interruption methods were evaluated:

1. **Immediate interruption**, where the interruption was presented immediately and forced the user to address the interruption immediately
2. **User-controlled interruption**, where the user controls when he would attend to the interruption
3. **Computer-controlled interruption**, where the computer predicted the best time for the user to attend to the interruption

4. **Scheduled interruption**, where interruptions were delayed and queued and displayed every 25 seconds for the user to attend

Although users responded sooner to interruptions when immediately interrupted, the best overall performance was when using the user-controlled and computer-controlled interruption methods. User-controlled interruptions also received the highest overall subjective satisfaction rating. McFarlane concludes that there is no single best interruption method, and the most appropriate method should be used depending on the context of the main task.

Similar to McFarlane's research, Adamczyk and Bailey (2004) used a task-based model to evaluate the effects of interruptions during different points in a task. In their study, three different interruption points were evaluated:

1. **Presumed best**, based on assumed cognitive low-points found through task modeling; most similar to McFarlane's computer-controlled interruption method

2. **Presumed worst**, based on assumed cognitive high points found through task modeling

3. **Random**, based on randomly displayed interruptions regardless of the user's current place in the task

Adamczyk and Bailey found that their model's presumed best interruption point was perceived by users as less annoying, less frustrating, less time pressure to complete the task, and less mental effort, than the other interruption points. Later work by Iqbal

and Bailey (2008) again showed that presumed best interruptions were less frustrating. This supports McFarlane's finding of computer-controlled interruptions having the best performance; however, Adamcyzk and Bailey also stress McFarlane's recommendation of fitting the interruption method with the context of the interruption and user task.

Fogarty et al.'s (2005) approach was similar to Adamcyk and Bailey's study. They developed their own interruption model based on user task observations and interruption response time of the main study task rather than using a standard task modeling approach. In their study, three interruption conditions were evaluated:

1. **Interruptible**, when users were expected to respond to interruptions immediately
2. **Engaged**, when users were expected to respond to interruptions after a short delay
3. **Deeply engaged**, when users were expected to respond to interruptions after a longer delay

Fogarty et al. found that their model could predict an interruptible user condition with over 70% accuracy. Some of the most predictable interruption conditions included task interactions when users recently resized a window, navigated a tree widget in the past five seconds, recently stopped typing within the past 20 seconds, and switching between windows in the past 15 seconds. This study also provides additional support of interrupting users when they are not engaged in a task, just in a different way than the empirical methods previously discussed.

Gievska and Sibert (2004) and Gievska et al. (2005) also developed a similar interruption model and evaluated it using two interruption conditions:

1. **Immediate interruptions**, when the interruption was presented immediately to the user
2. **Computer-controlled interruption**, when the computer predicted the best time to present the interruption to the user

Gievska and Sibert (2004) found that users who experienced computer-controlled interruptions committed fewer mistakes in the main task than users who experienced immediate interruptions. In the later study, Gievska et al. (2005) also found that immediate interruptions were perceived as being more annoying than the computer-controlled interruptions. Interestingly, contrary to other findings in the literature related to mental load and computer-controlled interruptions, they instead found that users perceived returning to the main task after an interruption more difficult during the computer-controlled interruption condition compared to the immediate interruption condition. However, their closer inspection of their data showed that users may have underestimated their perceived main task performance implying that other factors influenced the inflated rating of mental load.

Overall, all of the models presented show clear benefits of controlled interruptions and drawbacks of immediate interruptions; although, determining what type of controlled interruption and under what conditions to use certain techniques will depend on understanding the greater context of the main task and the interruption. Additional models that focus on context of use are described later in this chapter.

2.2 Interruptive User Interfaces

There are many ways to interrupt the user. A common way is through an interruptive notification message that draws their attention in order to deliver information. I describe the user interface for an interruptive software system in three conceptual components: information, behavior, and user interface. *Information* is the data that will be presented to the user by the notification system. *Behavior* is the logic and decision making executed by the system in order to determine how and in what way the user will be notified of the information. The *user interface* is the physical representation of the information according to the rules dictated by behavior.

2.2.1 Information

Information is an important aspect of a notification. Not all information has equal importance, urgency, or interest to the user. The context of the interruption can have an effect on the value of the information. However, even without fully understanding the complete context of the information and the interruption, general assumptions can be made about what information is important to users by developing models for use in design (Birnbaum et al. 1998).

Notifications should provide an adequate summary of information (Cadiz et al. 2002) so users can quickly determine how they should react to the notification. Although the information should be accurate and reliable (Berry 2003), abstracting the system-provided data into a more compact and efficient message will make the notification easier to read “at a glance” (Matthews et al. 2004).

Notifications information should also be timely (Berry 2003). Information delivered in a notification is often-time sensitive (Miller and Stasko 2002) and delays in the notification information delivery could reduce the value of the information and increase the cost of the interruption to the user. For example, a notification informing the user of the current temperature is useless if the data is out of date or inaccurate, thus creating a low-value interruption to a user's main task.

Some research focuses on the design of certain types of information in notifications, such as incoming email, because of the frequent need to have timely updates on changes to this type of information. Information which is marked with a high urgency or as newly arrived have been found to be an important type of information to users (van Dantzich et al. 2003). Importance is a contextual quality of notification information and can be difficult to define; but, specific sub-qualities of importance can be identified and used as a basis for assigning priority. For example, some of these related importance qualities include information marked with urgency (such as email), newly arrived information (such as an instant message), information which has met a time limit or expired (such as a task), or an expired bookmark (such as a file). Notification priority level (Matthews et al. 2004) can be used as a method for classifying information of varying levels of importance, allowing the notification system to decide how to best notify the user of new information.

2.2.2 Behavior

There are many guidelines available to help determine how the interruptive notification system interrupts the user and displays notification information.

Progressive disclosure of information (Brown 1999 p. 16) is a method for optimizing the amount of information displayed with the size of the display to increase user comprehension. An information summary is displayed by default and additional information details are provided on demand. For example, information such as sender and addressee of a message may be too much information in the notification user interface, and details such as those would be more valuable as hidden information available on demand (van Dantzich 2002). Gluck et al (2007) described a method of dynamically highlighting important and relevant information in the notification as a way to help the user make sense of compact information. Van Dantzich et al (2002) used color and symbols as a way to code and display more information in a notification. Cadiz et al (2002) described the use of tooltips and mouse-over popups as a method for providing additional details.

This information design concept of progressive disclosure can be built on beyond simply providing additional information details to the user. Functionality such as links to other information, software, or related services in the system could be provided by the notification as well (Berry 2003). Providing additional functionality helps the user react and respond faster to the information in the notification and possibly increase the value of the notified information.

The primary purposes of notifications are to provide awareness of changes in services outside the realm of the main task and to support multiple activities. Notification systems are meant to run as a support service while the user focuses on a main task (McCrickard 2003). Sometimes the distraction of a notification acts as a trigger to

switch main tasks (Iqbal and Horvitz 2007). There are a number of ways disruption to the main task can be mitigated, and they suggest several ways for the user to more easily return to their main task. Saving the state of the main task could help the user resume the suspended main task more quickly and easily. Providing a reminder or indicator of the suspended main task could help the user resume the task sooner and mitigate distraction costs of the notification. Also, a playback feature could help remind the user of previous actions in the main task before the interruption.

Several researchers promote the ability for users to configure different aspects of the notification behavior and user interface in order to better tune the notification system to their needs (Cadiz et al. 2002; Berry 2003). However, providing too much customization places an additional burden on users and forces them into the role of the designer (Nielsen 1983, p.12). Instead, designers should analyze the errors and types of configuration options users can change to discover where the notification system is failing.

2.2.3 User Interface

The user interface of a notification has a big impact on the experience of the user interacting with the interruptive system. The most important notification information should attract the user's attention since the information could be of high urgency, time-sensitive, or great interest to the user. *Attentional draw* is defined as the “amount of attention attracted by an interruption's notification method” (Gluck et al. 2007). Attentional draw is often used to describe the features of a notification user interface which affect the user's attention. Motion is an animation method that has high

attentional draw and can be used for delivering the most important and highest priority information (Matthews et al. 2003). Low priority notifications should have lower attentional draw than higher priority notifications. Static icons and other passive user interface elements are less disruptive methods that could be used for delivering less important and lower priority information (Matthews et al. 2003). Regardless of the priority level, the notification level must be easily recognizable in order for the user to quickly assess the priority of the information in the notification and respond accordingly (Berry 2003).

It is important for information to be accurate and up to date and to reflect the current system status (Berry 2003). Information that is frequently updated may be lower priority because frequent high priority notification would be distracting to the user. A consistent, but low attentional draw method is needed to provide the user with notifications of low priority information. Maglio and Campbell (2000) found that visual feedback is better than an auditory cue for indicating new information. The use of a notification indicator, "a passive device for conveying information status" (McCrickard et al. 2003) is a popular method for providing notification of status and updates to notification information as well as delivering notifications that require a low attentional draw (Cadiz et al 2002; Mankoff el al. 2003; Matthews et al. 2004). For example, the notification of new software updates could be provided as an indicator in the task bar. Software updates are useful information to the user but not such a high priority that the user must be interrupted from the main task to attend to immediately.

Movement is a challenging technique to use in the design of a notification user interface. Even when the notification is displayed in the user's periphery of visual attention, certain types of movement can have too much attentional draw and inappropriately distract the user from the main task. This distraction can affect user task performance (Maglio and Campbell 2000) and satisfaction of the notification system (van Dantzich et al. 2002).

Although movement affects the user, it can still be a useful technique. Different types of movements have different effects on the user (Maglio and Campbell 2000; McCrickard et al. 2001). Movement should not necessarily be avoided as Cadiz et al. (2002) recommend, but the appropriate combination of animations should be used to balance the need to attain the user's attention without undue distraction. High priority notifications have a greater need to gain the user's attention than low priority notifications, and the use of movement would be an appropriate method for gaining the user's attention.

Movement such as scrolling (both slow and fast speeds) is less distracting than other types of movement, and helps increase user comprehension of the information (Maglio and Campbell 2000; McCrickard et al. 2001). However, this movement also has a lower attentional draw than other types of movement and the user could miss updates to the information (Matthews et al. 2003). This limitation would make scrolling unsuitable for notifications that have a high priority for the user's attention (Berry 2003).

Pulsing, flashing, fading in and out, or suddenly appearing have much more attentional draw than scrolling movement. These are good techniques for quickly gaining the user's attention for high priority information (McCrickard et al. 2001).However, these techniques applied to low priority information can be annoying to users (van Dantzich et al. 2002).

The location of the notification on the user's display is also important. The notification should be in an area that the user will notice, but also in an area that is not too distracting, such as in the periphery (Mankoff et al. 2003). Notifications located in the top-left or bottom-right locations on the user's display are still in the periphery but in a location where the user will still notice change (Lim and Wogalter 2000). The center of the display is an area of high attentional draw (Lim and Wogalter 2000) and displaying notifications in this area should be reserved only for highest priority notifications.

An example of the combined use of movement and location would be in the case of notifying the user of an upcoming high-priority appointment. Ideally, the notification would appear, either as a pulse, fade-in, or sudden appearance, in the center of the user's display. An appointment is an important event, and a notification in the periphery without sufficient attentional draw could risk the user missing the notification and missing the appointment.

2.3 Interruption in the User's Context of Use

There is a small amount of research that looks at contextual factors in interruption. As you will see, there is a wide range of factors that may or may not affect the interruptive user experience, and many of these factors depend on context.

Measurements such as user performance and user satisfaction in controlled settings are the traditional methods to evaluate interruptive systems. However, anecdotal comments from the same researchers who use these measurements also indicate that these empirical measurements alone are insufficient and that a further understanding of the context is key (e.g., Adamczyk and Bailey 2004). A link between user performance and preference is demonstrated in usability engineering research (Nielsen and Levy, 1994), while relevant interruption research shows no link between user performance and preference (Booker et al., 2004). It is important to look at relationships between additional interruption factors. These relationships will provide a more holistic understanding of the effects of interruptions on users including why users should be interrupted in the first place. The following sections review previous work related to contextual factors of interruptions. Most of the work focused on contextual factors related to tasks and are described first. Additional contextual factors are then described.

2.3.1 User-Controlled Interruption

Gonzalez and Mark (2004) examined the effects of interruptions in a much broader context of work, rather than individual tasks, and showed users are often self-interrupting. They proposed a model for describing collections of tasks related to a

goal, called a work sphere. In a field study of task management, they found that work was very fragmented, and that users switched between most types of work spheres on average of every 11 minutes. These work sphere switches were both self-initiated interruptions by the users and interruptions due to external environmental factors. Later work (Dabbish et al. 2011) found additional evidence that user environment creates conditions for increased self-interruption. This is similar to the model for interruptions between tasks, except that the interruptions are user-initiated and that work spheres consider a collection of tasks related to a goal rather than a collection of sub-tasks related to a single task.

Iqbal and Horvitz (2010) also observed self-initiated interruptions in a field study of notifications and awareness. When interruptive notifications that were used to provide awareness of incoming emails were disabled, users often interrupted themselves in order to check for changes in email status. Although users acknowledged that interruptive notifications were disruptive, they also provided valuable awareness of services.

Early work by Adler and Benbunan-Fich (2011) explored the effects of negative user experience and self-interruption. They found that negative feelings during multi-tasking often lead to an increase in self-interruptions. Conversely, they found that less task switching and positive feelings lead to fewer self-interruptions and fewer task-switching associated errors. This shows how positive and negative user experiences have an effect on behavior related to interruptions.

2.3.2 Interruption Compensation

Sanders and Baron (1975) found that anticipation of an interruption may make users work harder to compensate for the cost of distraction the interruption creates. In two studies, they asked users to perform simple and complex tasks with different groups experiencing a different number of total interruptions. The more interruptions users experienced, the better their performance on the task. A more recent study from Gievska and Sibert (2004) replicated Sanders and Baron's results and described these phenomenon through the concept of compensation for interruption during a main task. Users who experienced more frequent interruptions adjusted their workflows by decreasing the amount of time away from the main task and by resuming the main task faster after interruption.

Iqbal and Horvitz (2007) provided additional insight as to why interruption compensation may occur. They found that users completed certain task interactions, such as paragraph completion while writing a document, more quickly immediately following an interruption than when performed with no interruption. They described this behavior as task stabilization, completing a task cycle and preparing an interrupted task so it is easy to return to later. Andrews et al. (2009) also examined task stabilization in a study that tested pre-interruption alerts. In their study, they informed the user of an upcoming interruption by sending out a minor alert before the actual interruption. They found that users who received the pre-interruption alert were able to resume the main task faster than users who did not receive a pre-interruption alert.

Both Czerwinski et al. (2000) and Fogarty et al. (2005) also informally observed task stabilization in their studies and found that users would first complete the current task interaction of the main task before attending to the interruption. Supporting task stabilization may be an important feature in an interruptive system. A smart system could help users complete small interactions that would normally be the source for main task errors, or to defer interruptions to between task interactions so that users do not need to stabilize tasks.

An experiment by Bogunovich and Salvucci (2011) explored the effects of time pressures on user-deferred interruptions. While participants tended to defer interruptions to a cognitive low point in their task, time pressures introduced additional interruption management strategies such as task stabilization to create a low point, and giving up and attending to the interruption during a cognitive high point if a potential low point is far away.

2.3.3 Relationship between Task and Interruption

It is unclear if there is a relationship between the main user task and the interruption task. In a series of experiments, Gillie and Broadbent (1989) found conflicting evidence for how interruptions that were similar or dissimilar to the main task affected user performance. As the main task in four experiments, users were asked to play a game that required them to remember a list of items in order to win. In the first two experiments, users were interrupted with mental arithmetic tasks of different length of which there were no significant interruption effects. In the third experiment, the interruption task required the users to speak words aloud that were presented on

the screen. This experiment found a significant interruption effect. During the fourth experiment, the methodology mixed arithmetic and language and asked users to decode arithmetic problem written out as words and then solve the problem. This experiment did not find a significant interruption effect. Although Gillie and Broadbent conclude that similarity and complexity of the interruption did have an effect on the main task, their inconsistent results leave doubt.

Mark et al.'s work (2005, 2008) described similar conflicting results. In the earlier study (2005), the researchers examined the nature of fragmented work. They found that interruptions outside the user's work sphere, a collection of tasks related to a goal, were more disruptive than interruptions that were related. A study by Ardissono et al (2009) also found that interruptions related to the user's current work sphere were less disruptive than interruptions not related to the user's current work sphere. However, a later study by Mark et al. (2008) directly compared the differences in interruptions related and not related to the user's work sphere and found no effects.

Related work by Adamczyk and Bailey (2004) found that the effects of a reading comprehension interruption were greater during a video comprehension task than word processing and search tasks. Although not statistically significant, they anecdotally discuss the possibility that the similarity of the main and interruption tasks may have contributed to the disruptiveness of the interruption.

2.3.4 Attending to Interruptions

Czerwinski et al. (2004) found several contextual factors affected the perceived difficulty of returning to the main task after attending to an interruption, such as the

type and complexity of the main task, the length of the main task, the time away from the main task due to attending to the interruption, and the number of interruptions experienced during the main task.

Cades et al. (2007) found that users resumed less complex main tasks faster than more complex main tasks. However, they could not completely attribute the increased time to resume the main task entirely to task complexity. While the main task difficulty may not have had a direct effect on the disruptiveness of an interruption, they instead suggest that the main task difficulty may have prevented rehearsal and learning necessary to complete the main task, therefore increasing the disruptiveness of an interruption. This suggests that interruptions may have a greater negative effect on tasks that require heavy use of short-term memory than tasks that have better cognitive support.

Iqbal and Horvitz (2007) found an interesting relationship between the time spent on the main task and the likelihood of a user resuming the main task after an interruption. The longer users had been working on a main task before an interruption, the sooner they resumed the task after attending to the interruption. For example, users who spent five to 30 minutes on the main task had 100% chance of resuming the main task within five to 15 minutes after attending to the interruption. Users who spent less than five minutes on a main task resumed the task within five to 60 minutes after attending to an interruption and had 10% chance of never resuming the main task. Iqbal and Bailey (2008) also found that users responded more quickly to interruption tasks if the interruption was scheduled as a breakpoint between main

task chunks. This work helps confirm Cutrell et al.'s (2000) work that found users interrupted earlier in a task were more likely to request a reminder after being interrupted, and Cades et al.'s (2007) work regarding task complexity. The longer users work on a main task, the less recovery time is necessary when returning to the main task after attending to an interruption.

Avrahami et al. (2008) also found a number of factors that affected the amount of time it took for users to respond to an interruption, such as salience of the interruptive window and content of the interruption message. Users responded faster to interruptions that had more prominent interruption windows and longer interruption messages. This indicates that content of the interruption may have an effect on the disruption and perceived value of an interruption.

2.3.5 Interruption Purpose and Content

Features in the content of an interruptive message sometimes have an effect on a user's response to an interruption. During interviews with users after an experiment, Iqbal and Horvitz (2007) found that users were more compelled to respond to certain types of interruptions, such as instant chat messages, faster than other types of interruptions, such as email notifications. Users described a “social obligation” regarding instant chat messages because they knew the author was available and probably waiting for an immediate response.

Avrahami et al. (2008) found similar results. They found that the content of the interruptive message was a strong factor in how fast users responded to the interruption. Users were faster to respond to interruptive messages that had longer

messages or contained a question. Users were slower to respond to interruptive messages that contained a link. As with Iqbal and Horvitz (2007), social obligation could describe why users in Avrahami et al.'s study were faster to respond to messages that were longer or contained a question. They described this behavior as social communication responsiveness, “the time until a person responds to communication, [possibly] affecting the ongoing dynamics of a conversation as well as participants' perceptions of one another.”

Longer interruptive messages may imply deeper involvement or the seriousness of a conversation, and a question may be asked by a participant who expects an immediate response. Conversely, links in a conversation may indicate less serious or novelty conversations that present a greater potential for distraction, thus a lower priority to respond to.

2.3.6 Value of an Interruption

Value seems to be an important contextual factor in understanding interruptions. Gluck et a. (2007) found a relationship between interruption context and interruption value. In their study, they found that interruptions with high attentional draw were perceived as less annoying when users found the content of the interruption valuable.

In a field study that measured the effects of interruptions during various tasks, Vastenburg et al. (2008, 2009) found a similar relationship between interruption context and interruption urgency. Interruptions with higher urgency were considered to be the most valuable type of interruption experienced by users. Urgency was the “primary indicator” for interruption acceptability. There was no significant link

between type of interruption and the interruption urgency. Context was the defining factor for determining interruption urgency, which translated into overall interruption value. Vastenburg et al. (2009) recommended taking in to account user activities when determining the best time to interrupt them. The importance of context suggests no single factor can be used to evaluate interruption qualities, and reinforces the need for investigating relationships between contextual factors.

2.4 Contextual Interruption Models

While the study of interruption context has been broad and incomplete, there are several interruption models that integrate context into their frameworks.

Grandhi and Jones (2009) propose an Interruption Management Decision Framework that is driven by context:

- **Social context** includes influences from the user's environment such as the location of the user, people around the user, and the nature of the social activity
- **Relational context** includes influences between the user and the interruption such as the purpose of the interruption, the circumstances of the interruption, and the value of the interruption to the user
- **Cognitive context** includes influences of the user's current cognitive demand and the cognitive demand of the current and interruptive tasks

Social, relational, and cognitive contexts influence an interruption cost-benefit evaluation that influences the predicted interruption value and the subsequent strategy

for delivering the interruption. However, the research is still a work in progress and has not been extensively evaluated.

A model for studying context in the user experience of mobile products was proposed by Kornhonen et al. (2010a).

- **Environment Context,** describes entities that surround the user.
- **Personal Context,** describes the physical and mental state of the use.
- **Task Context,** describes the activity the user is currently engaged in.
- **Social Context,** describes social aspects of the user context, such as friends, enemies, co-workers, and relatives.
- **Spatio-Temporal Context,** describes time and location of the user during an event.
- **Device Context,** describes attributes of the computing device in use.
- **Service Context,** describes online services and interoperability between devices and services.
- **Access Network Context,** describes characteristics of the network, coverage, cost, speed, and trust of an access provider.

This model was much more detailed in describing the context around a user than the Interruption Management Decision Framework. Kornhonen et al. were able to use this model to help explain influences (what they call “trigger events”) of contextual factors in the mobile environment they were studying.

A similar model also for examining the context of mobile environments was described by Moran and Fisher (2013).

- **Local Contextual Factors** are the "here and now". This includes factors such as embodiment, environment, and social factors related to the interruption.
- **Relational Contextual Factors** are properties of the interruption. This includes factors such as the message sender, message content, medium, timing, and presentation of the interruption.

While similar, this model is much more tailored to the studying the mobile environment than the Kornhonen et al. (2010a) model and is more focused on tasks and activities than general user experience.

Despite the existence of these models, there is very little related research. This could be because the models are relatively recent compared to more mature interruptions research, or that they are too specific to the researchers' foci that they are not generalizable to a larger body of interruptions research.

2.5 Summary of Related Work

The related work in interruptions and notifications builds an understanding of when to interrupt users, how to interrupt users, and why users should be interrupted at all.

Literature that focuses on interrupting users informs us of when to interrupt users. The best time to interrupt users is between main tasks and interrupting users during a task should be avoided. Not only do interruptions affect user performance and satisfaction, users can notice the difference in performance and express dissatisfaction in the system. There are also multiple ways to interrupt users between tasks, but the

best method is determined by the context of the interruption and the user's current task.

The design of interruptive user interfaces informs us on how to interrupt users. The context of an interruption may affect the value of the information and so how that information is displayed is very important to the success of the user interface. Various factors in the delivery and display of interruptive notification information have an effect on the value of the interruption and the cost of the interruption to the user. Information value provides some insight as to how to interrupt the user; for example, higher value information may use more distracting techniques than lower value information. Integrating functionality into the interruptive notification user interface may allow users to attend to interruptions more effectively and decrease the overall cost of the interruption and increase the value of the interruption.

Finally, limited research understanding the user's context of use helps us understand why users should be interrupted and the contextual factors that affect the interruptive user experience. Users are known to compensate for an interruption either by preparing a task for interruption or working harder on a task after an interruption. There also may be a relationship between the main task and the interruption task and how it affects the user. How the user attends to an interruption and how attending to an interruption affects the user often depends on the context of the interruption, such as what the user was doing at the time of the interruption in relation to the interruption itself.

While previous research has examined selected contextual factors that affect the notification user experience, there are few interruption models that include context, and none that focus on the interruption user experience of knowledge workers. Quantitative studies focused on single variables or simple relationships and qualitative ethnographic studies were often focused on a narrow domain. I attempt to address the gap between quantitative and qualitative research by using a mixed approach—creating an in-depth comprehensive understanding of notifications through the study of related contextual factors and their influences on the user experience. This mixed-method study resulted in a comprehensive model of contextual factors that affect the notification user experience.

Chapter 3: Statement of Research

Much of the interruption and notification literature is strictly empirical with a focus on simple factor relationships (e.g., task type, or task type + notification relatedness to task) but does not examine a larger context of use involving the complex interaction and relationships between multiple factors (e.g., task type + user role + importance of notification). Ultimately, software behavior and interface design depend on the context of the user's task and other contextual features. Some ethnographic research has explored how context-dependent factors influence how interruptions affect the user; however, much of the evidence is accidental or anecdotal – little work focuses on understanding context as the main research goal despite the fact that context has been identified as an important factor in understanding the effects of interruptions on users. The importance of understanding context is emphasized throughout the research even if it was not specifically studied (Adamczyk and Bailey 2004, Bogunovich and Salvucci 2011, Czerwinski et al. 2004, van Dantzich et al 2003, Gluck et al. 2007, McFarlane 2002, Vastenburg et al. 2008, Vastenburg et al. 2009). The identification of relationships between contextual factors and the lack of a context-aware model of interruptions reinforces the need for investigating these relationships in more detail than what has already been done.

My work fills the gap between the deep but out of context empirical understanding of specific factors and broad but shallow ethnographic understanding of factors within context. In my dissertation, I explore the contextual factors of the interruptive notification user experience. The goal of this research is to develop an understanding

for how context can be used to understand the user's interruption experience. This understanding of the interruptive notification context can ultimately lead to better design recommendations based on known relationships and influenced by contextual factors.

Modern design practices have shifted away from strictly a *usability* approach—efficiency, effectiveness, and satisfaction (ISO 9241-11:1998) measured in a laboratory setting—to a more holistic consideration for the entire user experience. *User experience* is defined as a user's "perceptions and responses that result from the use of or anticipated use of a product, system, or service" (ISO 9241-210:2009). There are different dimensions of characteristics about a product, system, or service that are external to the user experience that may affect how the user perceives and responds to a product, system, or service.

In this work, I define a framework of dimensions for the interruptive notification user experience context as (Figure 4):

1. **User:** are characteristics about the user that may affect how the user perceives and responds to an interruptive notification. An example user characteristic would be the role of the user when they use the computer, such as a student, a hobbyist, or a worker.
2. **Environment:** are characteristics about the user's role in the environment that may affect how the user perceives and responds to an interruptive notification more broadly than just the task, similar to a work sphere. For example, if a user is in a "working" environment, they will execute tasks,

consume information, and make decisions influenced by the fact they are "working".

3. **User Task:** are characteristics about the user's main (interrupted) task that may affect how the user perceives and responds to an interruptive notification. An example user task characteristic would be the type of task activities the user is engaged with.
4. **Notification:** are characteristics about the notification that may affect how the user perceives and responds to an interruptive notification. An example of notification characteristics would be the source of the interruptive notification or the content of the notification message.

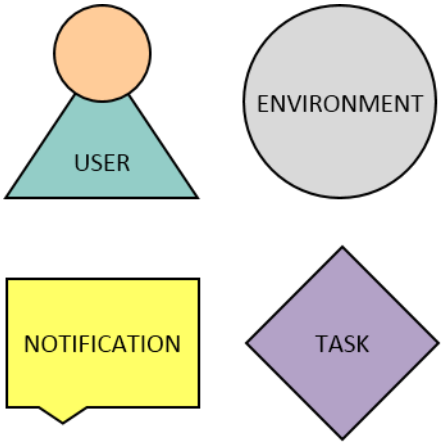

Figure 4: Dimensions of the Interruptive Notification User Experience Context

These context dimensions provide a framework in which to understand and reference the influence that contextual factors may have on the interruptive notification user experience. The dimensions were developed based on results from an exploratory study (Chapter 4) as well as previous work by Korhonen et al. (2010a) in mobile interruption context. In this research, a contextual factor is a variable that is external

to the user experience that is dependent on the user, environment, task, or notification.

I measure user experience through examining the emotions associated with the experience and the intent to continue the experience. Emotion is a visceral indicator of user experience. Emotion is an important aspect of the user experience and influences how users understand, interpret, experience, and interact with technology (Boehner et al. 2007, Forlizzi and Battarbee 2004). Future use is a behavioral indicator of user experience. The intention to use a technology, initially or continued use, is a common measurement in user acceptance models (Vankatesh et al. 2003).

In addition to providing a more informed picture of the overall context of use and a model describing the contextual factors and their interactions, this research provides two unique systems design benefits. First, some contextual factors, such as user and user task characteristics that can be easily collected from the user at a low cost. For example, a social network profile could indicate the user is a software developer which implies certain types of software development activities, such as many windows open at the same time while they work. This information would allow for explicit changes to the system based on these contextual factors by allowing the user to implicitly provide the information from a source that is already maintained (e.g., Facebook) as opposed to explicitly defining themselves in a profile survey. Second, other contextual factors, such as user task, work environment and notification characteristics, could be automatically collected and integrated into the system design without input from the user. By knowing the effects and relationships between these

contextual factors, interruptive notification systems can be optimized with little or no extra data input from the user.

The domains of interruptions and notifications are very broad and so I have restricted my area of focus to automated interruptive notifications such as pop-up notifications in a typical personal computing environment. These are a common type of interruption and they affect a wide range of users, especially knowledge workers who might experience greater drawbacks to interruptions than casual users. Research focused on these interruptions has the potential to produce results that have a wide-range effect.

3.1 Research Questions

In my work, I defined three research questions to frame how I approached understanding the relationships between contextual factors that affect the interruptive notification user experience and how that knowledge could be formalized in a model and applied to the design of interruptive notification systems.

> **RQ1: What are the significant contextual factors and factor relationships that affect the interruptive notification user experience?**

The review of related research identified possible contextual factors related to the interruptive user experience, but the research has not examined the relationships of these factors with other dimensions of the user experience in any depth, such as with characteristics of the user, user task, or user's work environment.

A user experience report (UXR) study identified contextual factors and the relationships between them that affected interruptive notifications of the user experience (described in more detail in the Methodology). This study was conducted with a mix of qualitative and quantitative methods in order to obtain breadth and depth in the results. A mix of methods that take advantage of a grounded theory approach cast an open net and explored what types of factors affect the interruptive notification user experience.

RQ2: How do these contextual factors interact with and affect the interruptive notification user experience?

While identifying individual contextual factors from the user experience is useful from an empirical perspective, understanding how these factors interact and affect each other and the user experience is necessary to make sense of these relationships and put the knowledge to good use.

A set of models of the interactions and relationships between contextual factors was developed to document and help understand the influences different factors exerted on the interruptive notification user experience. This model was then used to help understand and improve interruptive notification system design.

RQ3: How can an understanding of important contextual factors in the interruptive notification user experience be used to improve interruptive notification systems?

Additionally, the conceptual model helped explain the interactions and relationships between contextual factors in an interruptive notification system. However, a

practical application of the model is necessary to help designers. Interaction design guidelines were derived from the research findings and conceptual model as a way of providing practical guidance to designers. Guidelines also make this research more accessible to the HCI community.

3.2 Approach

This research aimed to explore the notification user experience from both ends of the methodological spectrum. A series of studies were executed to study the notification user experience, starting from a broad survey of general notification experiences (Exploratory Study), progressing to a more detailed look at notification experiences in a knowledge working community (User Experience Reports), to a detailed examination of the impact of interruptive notifications on knowledge workers (User Interviews), and how certain contextual factors influence the notification user experience (Notification Models) (Table 1).

Study Method	**Focus**	**Purpose**
Exploratory Study	General Users	High-level exploration of the notification user experience to test out survey questions and identify contextual factors to focus on in the more detailed UXR study.
User Experience Reports (UXR)	General Users Knowledge Workers	Broad survey of a range of notification user experiences within a knowledge working community, captured through a detailed experience report.
User Interviews	Knowledge Workers	Interviews with users to confirm or contradict conclusions from UXR analysis. Additional opportunity to explore the notification UX from the perspective of knowledge workers.
Notification Models	General Users Knowledge Workers	Application of the results from the UXR and Interviews that contribute to a better understanding of the interruptive notification system as well as present the results in a way that can be applied to

		similar interruptive notification systems.

Table 1: Summary of executed studies with user focus and purpose

A mixed-methods approach was utilized to develop an understanding of the notification user experience with breadth and depth. Qualitative methods were used to capture descriptive experiences while quantitative methods were used to confirm qualitative conclusions and offer additional insights (Table 2).

Study Method	**Data Collected**	**Analysis Strategy**
Exploratory Study	Survey responses Open text responses	Statistical analysis of survey responses (Descriptive, Chi-square, Correlation) Qualitative analysis of open text responses (Grounded Theory, open and axial coding) Structured analysis of open text responses (Rule-based coding)
User Experience Reports	Survey responses Open text responses	Statistical analysis of survey responses (Descriptive, Chi-square, Correlation, Complex contrasts) Qualitative analysis of open text responses (Grounded Theory, open and axial coding) Structured analysis of open text responses (Rule-based coding)
User Interviews	Interview chat logs	Qualitative analysis of interview text (Not Grounded Theory. Structured and open coding)

Table 2: Summary of analysis strategies applied to data collected from each study

These results were analyzed in the context of the previously discussed Notification User Experience framework. This framework provided context for understanding how contextual factors interacted with each other and influenced the user experience, as well as a context for presenting these influences in notification models (Table 3).

Data Collected (Study Method)	**Purpose**	**UX Dimension**
Participant demographics (UXR, Interviews)	Details about the user that may affect how the user perceives and responds to a notification	User
Participant environment (UXR, Interviews) Desktop screenshot (UXR)	Details about the user's environment that may affect how the user perceives and responds to a notification	Work Environment

Descriptions of typical user tasks (UXR, Interviews) Descriptions of task management during a notification event (UXR, Interviews)	Details about the user's tasks that may affect how the user perceives and responds to a notification	User Task
Descriptions of notifications (UXR, Interviews)	Details about the notification that may affect how the user perceives and responds to a notification.	Notification

Table 3: Data collected from studies and how it applies to Dimensions of Notification UX

This progressive approach helped me understand the problem area I was interested in studying while conducting an initial exploration of that space, investigate the notification user experience and identify significant contextual factors, and then understand how the contextual factors interact and affect the user experience in a way that can be applied to similar problem spaces (Table 4).

Research Question	**Data for Analysis**	**Expected Results**	**Role**
RQ0: (Understanding of problem space and formulation of research questions)	Data collected from exploratory reports: - Survey data - Experience data - User demographics	List of potential questions to use in user experience reports. List of potential contextual factors and relationships between factors to study in more detail.	Early understanding of the notification user experience
RQ1: What are the significant contextual factors and factor relationships that affect the interruptive notification user experience?	Data collected from user experience reports: - Survey data - Experience data - Desktop screenshots - User demographics	List of important contextual factors and relationships between factors	Core understanding of context and contextual factors
RQ2: How do these contextual factors interact and affect the interruptive notification user experience?	In-depth analysis of contextual factors and relationships from RQ1 that lead to conceptual models. Additional data collection from: - User interviews - User demographics	Conceptual model of how the contextual factors are interrelated and affect each other and characteristics of the user experience	Application of understanding to notification model.
RQ3: How can an	Analysis of results	Set of notification system	Application of

understanding of important contextual factors in the interruptive notification user experience be used to improve interruptive notification systems?	from UXR and Interviews Analysis of the notification models	design guidelines	understanding to the design of notification systems

Table 4: Summary of research approach to address research questions

3.3 Contribution Summary

In my work I explore contextual factors in the interruptive notification user experience using complementary qualitative and quantitative methods. This work builds and expands existing work that has focused more on individual factors in the lab (quantitative) and field (qualitative) rather than the complex interaction between and among factors. I accomplish this through the investigation of three research questions:

1. What are the significant contextual factors and factor relationships that affect the interruptive notification user experience?
2. How do these contextual factors interact and affect the interruptive notification user experience?
3. How can an understanding of important contextual factors in the interruptive notification user experience be used to improve interruptive notification systems?

In this dissertation, I studied a variety of knowledge workers who were involved in the KDE open source software project (described in Chapter 5: Methodology). While modern computing for casual users is moving towards a more ubiquitous and mobile platform, knowledge workers rely on desktop computers in order to do their jobs. The daily work of knowledge workers involves critical thinking, communicating with

people, and using productivity applications that are only available and best suited for a desktop environment. Notifications are an important service that helps knowledge workers successfully manage their tasks. Figure 5 summarizes the application of this research.

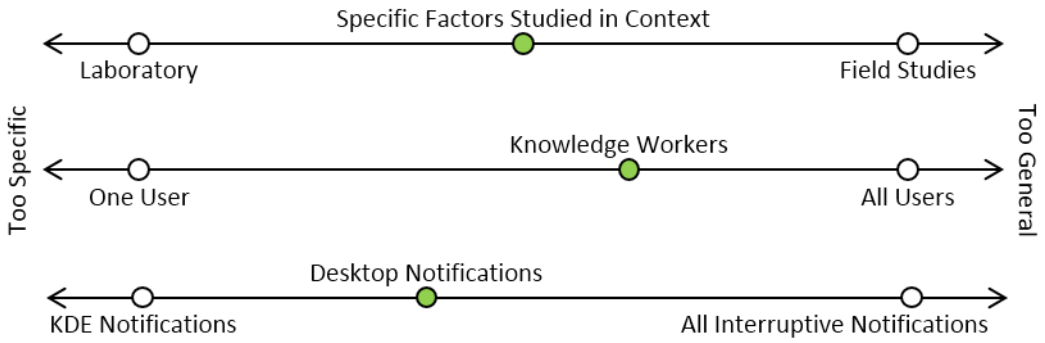

Figure 5: Summary of the application of this research

While the focus of my research was on people from the KDE community, the results could be transferrable to other domains and settings where software developer-type knowledge workers accomplish their tasks using desktop systems. Notifications will continue to play an important role in assisting desktop users, including knowledge workers, with managing their services. Continuing to investigate the interruptive notification user is essential for supporting a future knowledge worker-friendly desktop environment. The notification models and desktop guidelines developed as part of my work (presented in the Discussion) have the potential to impact the work environment, usability of notifications, and the general user experience of desktop system for a large number of users in the future.

Chapter 4: Exploratory Notification Study

An exploratory study was conducted early in the project to understand the research space and test ideas for more in-depth research. The purpose of the exploratory study was to explore the interruptive notification experience with a focus on understanding the context of the experience. Three general research questions guided the design and analysis of the study:

1. What is the general user experience of an interruptive notification? What types of notifications do users usually receive? How do users normally respond to notifications?
2. Are there any significant differences between different types of notifications? Are there any significant relationships between different types of notifications?
3. Are there any other factors that may contribute to a better understanding of the interruptive notification experience?

This study showed that it is possible to capture the interruptive notification context of use and understand the contextual factors that affect the user experience.

4.1 Methodology

4.1.1 Procedure

An online study was conducted using Amazon Mechanical Turk (AMT) (Appendix 1). AMT is an online crowd sourcing tool that provides a large participant population and the ability to host studies via the service. AMT was used as a way to gain access

to a more representative population sample and an alternative to the common approach of using college students. Participants complete Human Intelligence Tasks (HITs) that are small tasks requiring some type of input for evaluation. A study round is a collection period for multiple HITs from different participants. Each participant contributed one HIT to the study. It is also standard practice to run studies that need to collect many responses in multiple consecutive HITs. By running multiple studies, the study publish date is newer and so the study is listed in the first few pages of the HIT catalog, making the study easier to find and more attractive for participation.

4.1.2 Participants

Participants were recruited and paid through the AMT system. Participation in the study was limited to participants in the United States to help control for English language skills, and was limited to participants who had at least a 95% HIT approval rating (the percentage of HITs correctly completed) in order to exclude participants who are known to not follow instructions and provide low-quality responses. Participants were paid $.10 for completing the All-Notifications study and $.15 for completing the Social-Notifications study. Separating the studies into multiple rounds is a recommended strategy for AMT studies because newer studies requiring fewer responses tend to have better response rates than older studies requiring many responses.

4.1.3 Data Collection

Participants were instructed to answer a series of questions about a recent interruptive notification experience. Notifications were defined in the study as “Pop-up

notifications that are the little message boxes or bubbles that appear in the bottom-right corner of your screen that alert you of new information or events."

The study instrument (Appendix 2) was a web-based form that asked participants to describe a recent interruptive notification experience through a combination of open-ended (text) and closed-ended (selection or scale) questions about the details of their experiences.

1. Describe the most recent pop-up notification you received: (Open text)
2. Describe what you were doing at the time of the notification: (Open Text)
3. How long ago did you receive the notification? (Selection: <5 min, 5-10min, 10-30min, 30-60min, 60+min)
4. Select which type of notification you received: (Selection + Image: Bubble, Dialog, Unknown)
5. Describe the type of notification message: (Open text)
6. What application or service did your notification come from? (Open text)
7. Did you feel that you needed to take action or respond to the notification? Why or why not? (Selection + Open text: Yes-Immediately, Not sure, No)
8. Did you take action or respond to the notification? Why or why not? (Selection + Open text: Yes-Immediately, Yes-Not right away, No)
9. Rate the notification based on the following qualities: (5-point matrix: Important, Interesting, Urgent, Useful, Valuable)
10. Which of these qualities is the most important to you when receiving any notification? (Selection: Important, Interesting, Urgent, Useful, Valuable)

11. How often would you want notifications like the one you received in the future? (Selection: Always, Sometimes, Never)
12. Using one word, how would you describe the notification you received? (Open text)

A pilot of the study instrument collected 20 sample responses and showed that most notifications that participants received were from non-social sources, such as the computer and not as many from social sources, such as email. Since I was also interested in the social impact of interruptive notifications as a possible contextual factor I conducted the study with two versions of the same instrument. The All-Notifications version asked participants to respond based on *any* recent interruptive notification experience. The Social-Notifications version asked participants to respond based on a recent *social* interruptive notification experience. The study instruments were the same for both versions except that the instructions for the Social-Notifications part specified *social-only* interruptive notification experiences.

A total of 139 responses were collected. Sixty HIT responses for All-Notifications were collected over three studies (20 HITs per study) and 79 HIT responses for Social-Only Notifications were collected over three studies (each study was open until 20 *social* notifications were collected and an additional 19 *non-social* notification responses were collected). Since the *non-social* notification responses were still relevant to the study, and I did not intend to calculate the relative incidence rate of *social* notifications compared to *non-social* notifications, the data was not discarded.

4.1.3.1 One-Word Response

The final question of the study (Q12) asked participants to describe the notification they received using one word. One-Word-Response (OWR) is a word association technique that is a short, direct question that requests the participant to respond with a single word. Word association is an elicitation technique that aims to get an immediate reaction rather than a thought-out response. OWR differs from other survey question types in that it is a simple question with a simple response and requires no deliberation to respond to. Word association techniques can be susceptible to priming (Hines 1986), a memory effect due to a previous influence or exposure, and so the responses must be considered within the context of other influences in the study. While this type of question is not uncommon, we formalized the technique in this study in order to easily refer to it. The OWR in this study (Q12) was worded, "Using one word, how would you describe the notification?"

4.1.4 Data Analysis

4.1.4.1 Data Quality

Responses were reviewed to ensure the collected data was about a recent interruptive notification experience and not an experience similar to but not the same as interacting with an interruptive notification. Each response was evaluated based on two rules: First, if the interruptive notification was part of the main task and required a response before the user could continue this main task (e.g., a browser security alert requiring the user to accept a cookie before continuing); and second, if the response was a web-based pop-up (e.g., an advertisement). Responses that met one of these rules were discarded since participants did not follow the instructions. Of the 139

collected responses, 16 responses met one of these quality rules and were discarded resulting in a total of 123 responses used in the analysis.

4.1.4.2 Factor Coding

Coding rules for interruptive notification socialness were developed ad-hoc as part of the study design while OWR emotion coding rules were developed post-hoc in response to the emergent factor in need for additional analysis.

4.1.4.2.1 Notification Socialness

Participants were asked to describe a recent interruptive notification experience including what they were doing at the time of the notification and details of the notification (Q1-Q6). These details contained information about the application or service that sent the notification and what the notification was about, e.g. "*An incoming message from a friend on Facebook*" and "*A notification that I needed to update my anti-virus software*". From these descriptions, responses were coded as either social or non-social. If the interruptive notification came from a social application or service it was coded as a *social* interruptive notification. If the interruptive notification was not a social application or service it was coded as a *non-social* interruptive notification. Notification socialness was interesting because many notifications are a result of participating in social-related services.

4.1.4.2.2 OWR Emotion

Emotion was a post-hoc factor found during our analysis. OWR responses were coded based on an emotional dictionary that defined the positive or negative tone of the emotion (Hein 2010). OWRs were coded either *positive* for words with a positive emotional tone, *negative* for words with a negative emotional tone, or *descriptive* for

words that had no emotional tone and simply described the experience. Words that had an unclear emotional tone were further investigated by evaluating the context of the open-ended responses. For example, two cases of "*reminder*" were clearly *descriptive*, while one case of "*remindful*" was clearly a *positive* word when the context of the open-ended responses considered.

4.1.4.3 Statistical Analysis

The data collected from this study was mostly nominal data derived from responses or open text coding. The following statistical tests were used to analyze the data:

- **Chi-square Test of Independence**, determined if a relationship existed between factors when assumptions about the data were met.
- **2-sided Fisher's Exact Test (FET)**, determined if a relationship existed between factors when assumptions for Chi-square were not met.
- **Cramer's V correlation**, measured the strength of the relationship for 2x2 factor comparisons that were not binary and for multi-dimensional factor comparisons.
- **Phi correlation**, measured the strength of the relationship for binary factor comparisons.
- **Theta odds ratio**, measured effect size of the positive variable in the factor relationship.

4.2 Results

The following section provides the results and discussion of several interesting relationships between contextual factors that were discovered in the data.

4.2.1 Notification Socialness and Emotional Experience

This analysis was previously published in Paul et al. (2011).

A post-hoc analysis was conducted of the relationship between the socialness of an interruptive notification and the emotional tone of the words used to describe the experience through a One-Word-Response (OWR). Out of the 123 responses analyzed, 89 (73%) participants used emotional words to describe their notification experiences. There was a significant relationship between the emotional tone of a OWR response and the socialness of an interruptive notification experience and participants were 3.2 more likely to describe social interruptive notifications with positive words than negative words.

Even though the OWR question asked participants for a "description" of their experiences, most responses contained emotion. Of the 123 responses, 89 words (73%) had a positive or negative emotional tone with 58 positive words (24 unique) and 31 negative words (13 unique). "Annoying" was the most popular negative word (n=15, 48% of all negative words). There was no single most popular positive word, with the top five positive words as "informative" (n=9, 15% of all positive words), "useful" (n=7, 12%), "helpful" (n=6, 10%), "important" (n=6, 10%), and "exciting" (n=4, 7%). Table 2 lists the positive and negative OWR responses and Figures 3 and 4 show tag cloud visualizations of the distribution of popular positive and negative OWRs. The prevalence of emotion suggests that the interruptive notification experience had a significant emotional effect on participants such that their reactions to the interruptive notifications were emotional. Perhaps participants found it easier to

draw on an emotional word to describe their experience, which supports design literature that includes emotion as part of the interaction experience.

Positive Words		Negative Words
Informative (9)	Easy (1)	Annoying (15)
Useful (7)	Fast (1)	Unimportant (4)
Helpful (6)	Fun (1)	Boring (2)
Important (6)	Good (1)	Irritating (2)
Exciting (4)	Great (1)	Again?!! (1)
Cool (3)	Happy (1)	Bad timing (1)
Convenient (2)	Humorous (1)	Bothered (1)
Effective (2)	Necessary (1)	Distracting (1)
Efficient (2)	Polite (1)	Forgettable (1)
Interesting (2)	Remindful (1)	Pestering (1)
Pleasant (2)	Simple (1)	Time waste (1)
Discreet (1)	Thankful (1)	Untimely (1)
		Useless (1)

Table 5: Frequency of positive and negative One Word Responses in Exploratory Notification Study

Figure 6: Word cloud of top OWR positive words from Exploratory Notification Study

Figure 7: Word cloud of negative One Word Responses from Exploratory Notification Study

A Chi-square Test of Independence showed a significant relationship between the OWR emotional tone (positive/negative) and the socialness of the interruptive notification (social/non-social), X^2 (1, *N*=89) = 6.376, *p*=.012). A Cramer's V correlation showed a significant but weak relationship between emotional tone and socialness (r(89)=.268, p=.012). A theta odds ratio showed that social interruptive notification experiences were 3.2 times more likely to be described with a positive OWR word than a non-social interruptive notification. Table 6 provides a summary of the statistical analysis.

	OWR Emotion – Positive	**OWR Emotion – Negative**	**Total**
Social Notification	35	10	45
Non-social Notification	23	21	44
Total	58	31	89
Chi-Square	df=1	Value=6.376	p=.012
Phi	df=1	r=.268	p=.012

Table 6: Socialness X OWR Emotion in Exploratory Notification Study

4.2.1.1 Social Interruptive Notifications

Notifications from Facebook were the most frequently reported source of social interruptive notifications (n=31). These included interruptive notifications from all features of Facebook including chat, new mail messages, and other notices. Email (Gmail, Inbox.com, Outlook, Thunderbird, Yahoo!, but not Facebook messages) was the second most reported source of social interruptive notifications (n=18), followed by chat (AOL Instant Messenger and MSN Messenger, not including Facebook chat, n=5). More positive words were used to describe social interruptive notifications than negative words. Of the 45 social interruptive notification experiences, 35 were described using a positive emotional word compared to 10 that were described using

a negative emotional word. Many participants expressed the social benefits of social interruptive notifications, as one participant stated,

> "I like knowing when someone quotes me [on a website]" (OWR "informative")

Another participant described a social obligation,

> "I didn't want to make my friend wait; [I responded immediately because] it was polite" (OWR "humorous")

These results suggest that social interruptive notifications are likely to be a positive experience.

4.2.1.2 Non-social Interruptive Notifications

Software and security updates were the most common non-social interruptive notifications. Operating system updates from Windows (versions XP, Vista, and 7) and Mac OS X as the most frequently reported source of non-social interruptive notifications (n=18). Security software (Avast, AVG, Immunet, Kaspersky, McAfee, Microsoft Security, Norton) were a close second (n=15), followed by various software-related update services (Adobe n=7, HP n=4, Java n=4). However, there was no difference in the ratio of positive or negative words used to describe non-social interruptive notifications. Of the 44 non-social interruptive notification experiences described, 23 were described with positive words and 21 were described with negative words.

A further look into the experience of non-social interruptive notifications revealed mixed feelings about receiving notifications about software updates and security services. Some participants did not mind non-social notifications because,

> "It is always good to know your virus protection is working," (OWR "great")

Other participants expressed dislike because,

> "They interfere with what I was currently doing," (OWR "irritating")

Other factors may influence why one interruptive notification can be a better experience than another. For example, frequency of non-social interruptive notifications may be an important contextual factor. As one participant explained,

> "It's important to know that everything is working okay, but maybe not everyday," (OWR "boring")

Another participant stated,

> "The less often I get [notifications], the more likely I am to listen to them," (OWR "annoying")

This suggests two things about non-social interruptive notifications. First, that non-social interruptive notifications may be an emotional experience but not an overwhelmingly positive or negative one. Second, that non-social interruptive notifications may have additional factors that influence the overall experience; that is to say, context matters more for understanding the non-social interruptive notification experience and future research should look at these contextual factors to better understand users' reactions to non-social notifications.

4.2.2 Emotion as an Indicator for Similar Future Notifications

The relationship between the emotional tone used to describe the interruptive notification experience (Q12 code) and wanting similar future notifications (Q11) was explored.

A two-sided Chi-Square Test of Independence between the emotional tone (Positive, Negative) used to describe the interruptive notification experience and wanting similar future notifications (Always, Sometimes, Never) showed a moderate and significant relationship (X^2 df=2, p=.000; Cramer's V r(90)=.598, p=.000; Table 7). A Fisher's Exact Test of a relationship between emotional tone and wanting similar future notifications that tested only Always and Never responses continued to show a strong and significant relationship (FET: *p*=.000; Phi: *r*(46)=.850, *p*=.000; Table 8).

	Future – Always	**Future – Sometimes**	**Future – Never**	**Total**
OWR Emotion – Positive	30	21	1	58
OWR Emotion – Negative	2	17	13	32
Total	32	44	14	90
Chi-Square	df =2	Value=32.238	p=.000	
Cramer's V	df=2	r=.598	p=.000	

Table 7: OWR Emotion X Future (All) in Exploratory Notification Study

	Future – Always	**Future – Never**	**Total**
OWR Emotion – Positive	30	1	31
OWR Emotion – Negative	2	13	15
Total	32	14	46
Fisher's Exact Test	p=.000		
Cramer's V	3f=1	r=.850	p=.000

Table 8: OWR Emotion X Future (Y/N Only) in Exploratory Notification Study

There was a strong link between the emotional tone of how the experience was described and wanting similar future notifications. Participants were more likely to

want similar future interruptive notifications if they described the experiences with positive emotional words and were likely to not want similar future interruptive notifications if they described the experiences with negative emotional words.

Participants' follow up responses (Why or Why not?) for wanting similar future notifications (Q11) supported the relationship between emotional tone and *Always* or *Never* wanting similar future interruptive notifications:

> "It is important that my virus protection is up to date" Always, Positive
>
> "[the notification] is annoying and slows down my computer" Never, Negative

Participants who responded with *Sometimes* wanting similar future notifications had mixed responses:

> "I would like the ability to turn it off when needed" Sometimes, Positive
>
> "They might be important, but I don't want to be spammed" Sometimes, Negative

Although we have shown that emotional tone has a very strong relationship with wanting similar future notifications, the Sometimes responses indicate additional contextual factors contribute to what a desirable interruptive notification may be. The influence of additional contextual factors in the interruptive notification experience is consistent with what was found of the relationship between emotion and social

interruptive notifications (Previous section; Paul et al. 2011). This proposal aims to study these additional factors.

4.3 Discussion

4.3.1 Contributions

Understanding the relationships between rich contextual factors in the interruptive notification experience may help us design better interruptive systems. For example, measuring emotion in an interruptive notification experience could be a way to learn more about desirable interruptive notifications. This knowledge could then be used to design and evaluate interruptive notification systems.

For example, the results show that interruptive notifications had a significant emotional effect on the user experience. Also, interruptions from social software were more likely to be a positive user experience than interruptions from non-social application sources. However, there seemed to be multiple contributing factors as to why non-social notifications may have had more negative responses that must be examined in more detail. In the case of an indicator for wanting similar future notifications, the results showed a strong relationship with emotion. Interruptive notifications with a positive user experience were very likely to be interruptions users would want again in the future.

The results also show that understanding the link between emotion and wanting similar future notifications is useful knowledge for designing an intelligent interruptive notification system. A system based on emotion would be able to adjust and readjust future interruptive notification behavior depending on how participants

respond to similar notifications. Emotion in this study was easily captured through a method called a One Word Response. However, as I better understand the relationship between emotion and other interruptive notification factors, such as socialness, we will be able to implicitly infer relationships through contextual knowledge in the environment.

4.3.2 Limitations

There were several limitations of this exploratory study that are acknowledged which affect the interpretation of the results and provide methodological lessons learned for the main study. The purpose of the exploratory study was to collect information about recent experiences of interruptive notifications. The nature of our methodology may have resulted in participants to *recall* their experiences (i.e., remembering a past event with possible inaccuracies and biases in the recollection) rather than to *report* their experiences (i.e., easily stating facts from a recent event). A study design with a different methodology could better support reporting and result in different OWR responses or different emotional content, i.e., emotion will still be a significant factor but may have significant relationships with different contextual factors.

Asking participants to rate most important notification message characteristics did not turn up anything significant. This could have been a limitation of the factors themselves (they were not defined and could be participant-defined in different ways) or the way the factors were measured (on a closed-ended 1-5 scale rather than open-ended questions).

Emotion was not a planned study factor and was analyzed post-hoc. Due to the study methodology and the post-hoc nature of our analysis, a baseline of the participants' emotional state before and after the interruptive notification experience was not measured. This type of comparison is common in emotional design research and necessary for establishing ground truth for complex analysis. However, emotion is not the focus of my research and I do not intend in diving deep into the emotional analysis and will not capture an emotional baseline in future research.

While the OWR and other study quests were descriptive in the way they were presented to participants, there was possible evidence of word priming. Some of the qualities participants were asked to rate in the main study appeared in the OWR responses as emotional words (e.g. useful and interesting). However, priming is not always a negative effect and could be used as a methodological strategy. For example, in order to control context of responses, participants could be primed in a way to influence the scope of how they respond. I will need to keep this in mind when analyzing OWR data in the main study, such as watching for keywords that occur in the data collection questions and the interruptive notification message and analyzing them appropriately.

4.3.3 Impact on Future Work

This exploratory study provided important feedback that affected the design of the main study methodology. For example, the exploratory study showed that contextual factors of interruptive notifications can be identified through qualitative and quantitative methods. It provided support that the proposed methodology can generate

data to study the proposed research questions. The exploratory study also identified several contextual factors that may be of interest to investigate in future work. For example, knowing that response behavior and emotion may be interesting variables influenced the design of the data collection instrument in the proposed methodology. The exploratory study showed that 123 data points is sufficient for finding significant relationships between contextual factors. Knowing the power necessary to find significant results is an important guideline for balancing the amount of data to collect with the level of effort required for analyzing qualitative data. Finally, the exploratory study tested potential questions that could be integrated into a diary study. For example, the exploratory study showed a very strong link between feeling the need to respond to a notification and actually responding to a notification. It may be enough to ask the participant if they responded to the notification without having to ask if they felt the need to respond.

Chapter 5: Methodology

While previous research has examined selected contextual factors that affect the notification user experience, no comprehensive model tailored for knowledge working has been published in the literature (more detail in Related Work). Quantitative studies focused on single variables or simple relationships and qualitative ethnographic studies were often focused on a narrow domain. I attempt to fill this gap between quantitative and qualitative research by using a mixed approach—creating an in-depth comprehensive understanding of notifications through the study of related contextual factors and their influences on the user experience.

This research employs various research and analysis approaches in order to build on current interruption and notification research and provide new contextual insight into the influences to the interruptive notification user experience. First, a user experience report study helped establish an understanding of the interruptive notification context and provides a collection of important factors and relationships. Then the development of a conceptual model explained how the contextual factors were interrelated and affect each other and the user experience. Finally, guidelines derived from conceptual model supported the immediate application of the results of this research to interruptive systems design.

5.1 User Experience Report Study

The first phase of this research consisted of a User Experience Report (UXR) study of the KDE notification user experience (UMBC IRC, Appendix 3).

A UXR is a type of sampling method (Consolvo and Walker 2003) in that a report is completed *in situ*, soon after the participant experiences the study phenomena (Korhonen et al. 2010a, Korhonen et al. 2010b). The participant completes an experience report that is often structured as an open-ended survey to guide participant responses. Experience sampling is an effective way to study emotion, a critical factor in user experience (Demir et al. 2009). A UXR is different from a diary study in that it is not an ongoing record of experience. Instead, a UXR is anchored to a single experience of the study phenomena and can be collected for single or repeated experiences. The procedure of a UXR study is often structured so that reporting occurs soon after an experience where some diary studies suffer from reflection of an experience that did not happen close to the time of recording the diary entry.

Participants were asked to complete a UXR immediately after experiencing a notification. The UXR was structured to collect key information about the participant's notification experience, as well as to provide sufficient open-text opportunities for them to elaborate.

I measure user experience through examining the emotions associated with the experience (UXR Q5 One Word Emotion, explained later) and the intent to continue the experience (UXR Q4 Future Notifications, explained later). Emotion is an important aspect of the user experience and influences how users understand,

interpret, experience, and interact with technology (Boehner et al. 2007, Forlizzi and Battarbee 2004). The intention to use a technology, initially or continued use, is a common measurement in user acceptance models (Vankatesh et al. 2003).

5.1.1 Participants

Participants in the UXR study were contributors (this includes developers and non-technical contributors such as designers and translators) who participate in the open source community surrounding KDE[1] as well as users of KDE. KDE is a very large, a very distributed, and a very social open source community made up of many smaller projects. The KDE community utilizes various types of social and non-social web services to help collaborate and communicate. These services are critical to help distributed teams work together, but also generate a large amount of interruptive notifications. Each participant provided one response.

Although KDE contributors are highly skilled computer users (not usually good participants for a general technology study), they participate in a unique and extreme work environment in which they must suffer interruptive notifications in order to maintain awareness of the community and collaborate with fellow project contributors. Their role as a knowledge worker, including their behaviors and perceptions (strategies for perceiving and adapting to notifications), may provide interesting insights to how interruptive notifications affect other types of knowledge

1 KDE is not an acronym (similar to how IBM no longer stands for International Business Machines)

workers who are involved in software development. Also, general KDE users tend to be more technically competent than the every-day user.

This research focused on knowledge workers that are primarily software developers and is limited in the assumptions it can make about all knowledge workers and casual users and may not be generalizable past software developers. For example, the characteristics of software developers are probably not the same knowledge working characteristics of a tax accountant. While software developers have characteristics specific to their work, they share common traits with other knowledge workers such as a need for concentration, deep thinking, and a sensitivity to interruptions. A benefit (or drawback) to using KDE contributors and users as participants is their knowledge of how the system works. Their technical knowledge and knowledge of the system may give them a vocabulary to help describe their experiences in more detail. Or in the case of developers, their personal connection to the software may make them hesitant to criticize their own work. I believe that their desire to improve the KDE notification system combined with their trust in my history with the KDE project (described in more detail in the next section) enabled KDE contributors and users to be informed, but critical participants in this study.

5.1.1.1 KDE and the Open Source Software Community

Open source is a software licensing philosophy which believes the human readable code source of software should be available for the public to freely install, modify, or redistribute. The term "open source" can also refer to the community and development practices of thousands of free/libre/open source software (FLOSS) projects that subscribe to this philosophy and license their software under one of the

many available software licenses. Open source projects tend to have communities that support highly distributed development and rely on online communication tools to support collaboration and development. People contribute to open source projects for many reasons, including as a place to gain experiences, an outlet for technical creativity, a place to join a community of like-minded people, and for material or monetary remuneration (Lakhani et al. 2005).

KDE is a desktop environment similar to Windows and Mac OS X. It produces software and services that follow a similar look and feel that provides a unified user experiences. KDE has its own notification system through which all KDE applications send message through. This system forces all notifications to have the same look and feel, constrains notification behavior to the same set of rules, and manages notifications through a common configuration system.

One drawback to engaging with the open source community is its lack of gender diversity. While the number of women in science, technology, engineering, and mathematics careers[2] is approximately 26% (NSF 2011), the number of women who contribute to open source projects[3] is estimated at 1.5% (FLOSSPOLS 2006). The number of women contributors in the KDE community[4] is estimated at 10% (KDE 2012). Although the number of women in the KDE community is above the average

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2 This NSF WMPD study reports on women only within the United States.

3 The FLOSSPOLS survey targeted Western European participants with some participation from other countries (through a participant's involvement in European-centric FLOSS projects).

4 While KDE is a primarily Western European project, it has significant participation from the United States, India, and Brazil.

FLOSS project, it is well below the normal and STEM population distributions. Therefore there are limitations in how far this work can generalize gender similarities or differences.

My role in the KDE community is that as an independent researcher but also a contributor. Since 2005 I have contributed to KDE as a designer and community leader. I began contributing to the KDE project through the KDE Usability Project, then lead the project from 2006 to 2012. I was also on the KDE e.V. board of directors which elevated by status and responsibility in the community. Many developers know of me and of my usability work in the community. It was this social status that allowed me to conduct a study of the KDE community. My personal relationships with developers helped me promote the study through the re-Tweeting of recruiting messages by influential community members, and recruit to interview participants on IRC.

5.1.1.2 Recruitment

KDE contributors and users come from many countries around the world with many developers from Western Europe, India, and Brazil. Recruitment makes considerations for English-speaking skills. Advanced English language skills are common in this multi-national community due to constant cross-cultural communication and advanced Internet skills. Recruitment included participants from the United States, United Kingdom, and Northern Europe in order to maintain cultural consistency. Cultural differences, such as in the perception of time (linear versus circular) (Graham 1981) may affect how participants perceive and respond to the

interruptive notification. Cultures from the United States, United Kingdom and Northern Europe share similar concepts of time (linear).

Recruitment messages were sent to several KDE community and project mailing lists, Twitter feeds, web forums, and blogs. Both KDE contributors and KDE users were targeted.

5.1.1.3 Participant Incentives

KDE contributors were interested in participating in this study for many reasons. First, the results of this research will directly impact the usability of KDE. The research-based guidelines would help improve KDE's own interruptive notification system. Second, the developers could also be interested in participating for altruistic purposes. Research and open source software are similar in that pursuits in both tend to have benefits to people at low or no cost. Being able to contribute to knowledge building that will provide a benefit for many people is an attractive quality. Finally, participants would help earn donation money (1€ per valid UXR submitted) for KDE, an organization they care about.

5.1.2 Instrument

The user experience report study was executed as a web-based survey hosted on Survey Gizmo. The survey form administered the informed consent and instructions. The following is a list of the UXR study questions:

- About the Notification
    1. Upload a screenshot of your KDE desktop as it was when you received the notification.

2. What was the notification about?
3. What service or application sent the notification?
4. Would you want a notification like this again in the future? Why or why not?
5. Using one word, how would you describe your overall notification experience?

- About Your Task

6. What were you doing at the time of the notification?
7. Did you stop what you were doing when you received the notification? Why or why not?
8. Was the notification related to the task it interrupted? Please explain.
9. What best describes your use of the computer at the time of the notification?

- About Yourself

10. Job Role/Title
11. Age
12. Gender
13. Country
14. Computer Type
15. English Language Proficiency
16. Education Level
17. Role in KDE

The complete study instrument is provided in Appendix 4. A summary of the questions and the user experience dimensions (user, task, notification, and environment) they contributed to are listed in Table 9.

UXR Question	UX Dimension	Factor	Values
Q1: Upload a screenshot of your KDE desktop as it was when you received the notification.	User Environment	Default Desktop Layout	Default Not Default
Q2: What was the notification about? Q3: What service or application sent the notification?	Notification	Notification Socialness	Social Not Social
Q4: Would you want a notification like this again in the future?	Notification UX	Future Notifications	Yes No (It Depends)
Q5: Using one word, how would you describe your overall notification user experience?	Notification UX	OWR Emotion	Positive Negative
Q6: What were you doing at the time of the notification?	User Task	Current Task	Open
Q7: Did you stop what you were doing at the time of the notification?	User Task	Interruption of Current Task	Stopped Current Task Did Not Stop Task
Q8: Was the notification related to the task it interrupted?	User Task Notification	Notification Relatedness to Current Task	Related Not Related
Q9: What best describes your use of the computer at the time of the notification?	User	Working Role	Working Not Working
Q10: Job Role/Title	User	User Role	Open
Q11: Age	User	Age	18-24 25-34 35-44 45-54 55-64 65+
Q12: Gender	User	Gender	Male Female
Q13: Country	User	User Country	Open
Q14: Computer	User Environment	Computer Type	Laptop Desktop Tablet Phone
Q15: English Language Proficiency	User	English Language	Little/None Conversational Fluent

			Native
Q16: Education Level	User	Education	High school Some college College Graduate/Professional
Q17: Role in KDE	User	Contributor Role	Contributor Non-Contributor

Table 9: KDE Notification User Experience Report Questions and Matching User Experience Dimensions, Factors, and Values

Submitting a desktop screenshot was optional. Participants were instructed to minimize or hide personal information that was visible in their screenshots. The study instructions suggested minimizing windows with personal information; some participants used graphics programs to censor personal information with color blocks or blurring. This procedure was not unfamiliar for many participants since sharing screenshots of personal desktops is a common activity in open source communities. Self-censoring may have led to changes in the screenshots that could have affected the analysis and interpretation of the screenshot data. This was an acknowledged and accepted limitation to obtain the richness of personal desktop screenshots while preserving the safety and privacy of participants.

5.1.2.1 Participation Selection Bias

Participants were asked to submit a UXR shortly after the notification experience. Participants were allowed to choose which notification experience to report. This may have lead to a sampling or selection bias of the types of notification experiences collected by the UXR study. Participating in the study was a type of interruption and disruption to participant's tasks. Participating in the study required a participant to stop what they were doing and complete the UXR. As a result, participants may have picked and chosen which notification experiences to report on versus other

notification experiences that would have been greatly disrupted. However, the quality of responses by participants and the large number of experiences collected in the UXR provided greater benefits than the drawback to potentially missing certain types of experiences.

5.1.3 Pilot Testing

5.1.3.1 Pilot Test

A multi-phase pilot test was conducted to evaluate the study instrument for potentially confusing instructions, procedures, and question phrasing.

During the first part of the pilot study six participants completed the UXR with real and sample data. These participants were easily accessible friends and family and not part of the KDE project. They provided feedback regarding question phrasing and errors in the study instrument. Minor changes were made to the study instrument, such as clarification of instructions, question phrasing, and web-based form errors. These participants participated to test the instrument and not necessarily provide value UXR data and so the data from this first pilot test of the instrument was discarded.

The second part of the pilot test was conducted as a soft release of the main user experience report study. Participants were recruited from one of the target KDE mailing lists used for participant recruitment. 16 participants completed the UXR and provided additional feedback that lead to clarifications of instructions, question phrasing, and web-based form errors. Minor changes were made to the study instrument, such as clarification of instructions. None of these changes were deemed

significant enough to change how participants responded. Data from this second part of the pilot test was not discarded and included in main study analysis.

5.1.3.2 User Experience Report

Participants were recruited through various KDE community social media as previously described. Participants were provided a link to the UXR in the recruiting message. Institutional Review Board (IRB) consent was administered through the UXR (Appendix 3). Once participants completed the UXR, they had the option to indicate if they were interested in being contacted for future research; specifically the post-UXR interviews. A donation to the KDE e.V.[5] was made after the UXR responses were reviewed for quality. A total of 239 responses were collected (including the 16 pilot responses). Four responses were too incomplete to analyze and were rejected for a total of 235 valid responses.

5.1.4 Data Analysis

A mix of quantitative and qualitative analysis methods were used to determine the results of the study. The general analysis strategy was to first analyze the qualitative data to discover themes in the data and then conduct quantitative analysis to explore statistical support for the themes. Additional post-hoc analysis exploring the quantitative data that was not indicated by the qualitative analysis was also conducted to explore any significant relationships that did not occur in the qualitative data. This qualitative-quantitative process was conducted iteratively as an understanding of the

[5] An eingetragener Verein is a German "registered association" such as a corporation and is often used for registering non-profit organizations similar to U.S. 501(c)(3) organizations.

results was developed. The purpose of this strategy was to support a Grounded Theory approach for analysis and to not bias the analysis by first looking for significant quantitative results and then looking for evidence in the qualitative data. Grounded Theory is an analysis approach that does not make assumptions about the data (hypotheses) and aims to develop an understanding of the phenomena through evidence that "bubbles up" in data analysis (Creswell 1997, Corbin and Strauss 2007).

5.1.4.1 Qualitative Data Analysis

Open-text responses were qualitatively analyzed to build an understanding of the data. The primary analysis method used to achieve this understanding is through iterative mixed-method coding that starts with a coding scheme based on data collection questions and evolves the coding structure as themes emerge (the grounded theory part). Any themes that may emerge as a contextual factor will also be selectively coded in order to be able to use it as a nominal variable in statistical analysis (similar to how emotion was coded in the Exploratory Study).

5.1.4.1.1 Open Coding

Open coding is an unstructured coding method that was conducted based on a Grounded Theory approach. The open codes in this part of the analysis were developed on an ad-hoc basis as themes evolved during analysis and an understanding of the data was developed. That is, open codes were not just generated in the beginning of the analysis, but throughout the analysis process as new themes emerged or existing themes developed.

The following procedure was used for open coding. First, a new code was created for any new theme identified. A theme for open coding was an interesting phenomena or trend to analyze in more depth. An open code could be created at any phase of the qualitative analysis process. Open coding was iterative with many passes through the data. The order of the data (both in terms of question and response order) were counter-balanced to ensure complete and even coding. Open coding was conducted on all open text responses from the UXR (Q2, Q3, Q4 Explain, Q5, Q6, Q7 Explain, Q8 Explain, Q9 Other).

Two researchers (myself and Dr. Anita Komlodi) each coded 100% of the data using an open coding approach. Inter-coder reliability could not easily be calculated because open coding was conducted using a variety of tools, including NVivo, text documents, and paper and markers. The two researchers discussed the common and differing open coding themes and created a final set of open coding themes. These themes were further developed and analyzed in Axial Coding.

The following is a list of open coding themes identified in the UXR data:

- "It depends…" Conditions to receive or not receive a notification
- Interesting Participant Comments
- Task Management (including multi-tasking and task switching)
- Notification Message Information
- Subjective Qualities of Notifications
- Social Context
- Music Players

- UX/UI Comments and Suggestions
- UXR Participation as an Interruption

5.1.4.1.2 Axial Coding

Axial *coding is d*etailed coding of a theme or faceted coding within a structure (Strauss and Corbin 1998). The axial codes in this anal*ysis were create*d on an ad-hoc basis as details and features in the themes from the open coding emerged. The axial codes were either directly mapped to open codes, sub-themes of open **codes, or cross-cut themes across mult**iple open codes. Coding was iterative with many passes through the data and order was counter-balanced to ensure complete and even coding. *This proces*s included using keyword searches to identify and code terms.

Two researchers (myself and Dr. Anita Komlodi) coded 100% of the data. One researcher conducted only one pass of axial coding (Dr. Anita Komlodi) while one researcher conducted iterative coding as the coding scheme developed (myself). Similar to the procedure for Open Coding, the two researchers discussed the common and differing axial coding schemes and created a final set of codes and sub-codes.

The following themes were coded in detail (expanded in Appendix 5):

- Notification Information Message (Q2)
- Social Notifications (all questions)
- Task Management (Q7 and Q8)
- User Interface Comments (all questions)
- Task Interruption due to Notifications (Q7)
- Conditions to Receive a Notification (Q4)

- Awareness (all questions)
- Multi-Tasking (Q7 and Q8)

5.1.4.2 Quantitative Data Analysis

Two types of data were analyzed using quantitative statistical methods. First, qualitative data was quantitatively coded for descriptive statistics (counts) or as categorical variables (for example, OWR Emotion) to be used for within-group comparisons. Second, quantitative data collected through the study instrument (categorical data from the survey) was used in standard statistical tests.

The following sections describe quantitative analysis strategies with expected contribution to the overall analysis.

5.1.4.2.1 Descriptive Statistics

Descriptive statistics such as counts, means, standard deviations, and percentages provide a quantitative perspective on what exists in the data. For example, descriptive statistics were used in the Exploratory Study to understand how many and of what type of emotional words participants used to describe their emotional interruptive notification experiences. A similar list of numbers would be cataloged to help provide a quantitative perspective in the Field Study data.

5.1.4.2.2 Significant Factor Relationships

Qualitative data collected in this study (either through direct data collection methods or coding of factors) was analyzed to determine if there was a significant relationship between two factors. Categorical factors are text-based values derived from UXR survey questions or qualitative data that can be counted and compared in a quantitative way. The following statistics are able to tell us certain relationships

between factors exist with a certain level of confidence and not be due to chance. The lack of a significant relationship does not mean that a relationship does not exist, just that we cannot know if what we see is due to chance.

- **Contingency tables,** display count data for each factor as well as provide a heuristic for interpreting the statistics. Important ratios between columns, between rows, and between columns and rows indicate qualities about the factor relationships. For simplicity, only the relationships relevant to the discussion of notification user experience will be discussed even though there may be additional (obvious or irrelevant) relationships as well.

- **Chi-square Test of Independence,** shows if there is a significant relationship between independent factors when assumptions about the data are met. If the sample is too small (less than 5 in any one contingency table cell) then a Fisher's exact test of independence can be used. (Agresti and Finlay 1997; McDonald 2009, 57-63).

- **2-sided or 1-sided Fisher's Exact Test (FET),** determines if a relationship existed between factors when assumptions for Chi-square are not met, usually when there is a count of less than 5 in a contingency table cell. (McDonald 2009, 70-75)

- **Cramer's V Correlation,** provides the strength (statistical power) of a significant relationship. In this work, relationships between .0 and .3 are considered weak, between .3 and .6 are moderate, and between .6 and 1.0 are

strong. This interpretation is on the conservative range of Cramer's V interpretation (other work has ranged from .3 as strong to .7 as strong (Botsch 2011, Garson 2008, Ratner 2013).

- **Contrasts** are a way to test if a relationship exists within a group. It is a way to see if a relationship that may not exist in the study population (no significant statistic) exists in a subset of the population. Post-hoc contrasts and grouping are commonly used with nominal data and combined with the Chi-Square test.

5.1.4.2.3 Structured Coding

Structured coding is a systematic coding method based on a pre-existing coding schema, rules, or theoretical construct. The following procedure was used for structured coding. Data was coded based on pre-defined structured codes. Sometimes new open codes would be defined as an understanding of the data developed and new insights were found. Structured coding was iterative with many passes through the data. The order of the data (both in terms of question and response order) were counter-balanced to ensure complete and even coding.

One researcher (myself) coded 100% of the data based on the following rules:

- **UXR Survey Questions (Q1 … Q17).** Responses were coded with the question they came from to provide reference and context during analysis.

- **One Word Response Emotion (Positive, Negative).** The One Word Response (OWR, Q5) was coded *positive* or *negative* based on an emotional word database. Words that were not emotional were not coded. There were a

few cases of ambigu*ity whe*re a *word cou*ld either be positive or negative depending on the context. This was resolved by examining the description of the notification (Q2) for emotional tone and the open text response for wanting similar future notifications (Q4) for context. If a clear emotional context could not be determined it was not coded.

- **Notification Socialness (Social, Not Social). S**ocialness was defined as a notification tha*t suppor*ts i*nteracti*on or communication with another person. Descriptions from Q1-Q6 (describe a recent notification experience) were coded. For example, a notification about a new email is a *social* notification while a notification about not being able to connect to the email server is a *not social* notification. This rule is different from the Notification Socialness coding rules in the Exploratory Study.

- **Working Role (Working, Not Working).** Participants were asked to select what they were doing at the time of the notification (Q9). Responses from this question were separated into two groups: People who were working (Working, Working from Home, At School, Working on Schoolwork), and people who were not working (At Home, Other)

- **KDE Contributor Role (Contributor, Not Contributor).** Participants were asked to indicate if they were a KDE developer, a non-coding KDE contributor (such as a designer or translator), KDE user, and KDE supporter (someone who donates money or advocates for KDE) (Q17). These categori*es were* not exclusive and participates could select *one or* more options.

Contributors were coded as *people* who indicated they contributed to KDE, either *as a KD*E developer or non-coding KDE contributor. *Not Contributors* were coded as people who indicated they were a KDE user and/or KDE supporter, but did not indicate that they were also a KDE developer or non-coding KDE contributor.

- **Default Desktop (Default, Not Default)**. Desktop screenshots were analyzed to determine if a participant's desktop layout was using the default KDE layout or a customized layout. *Not default desktop*s included screenshots that indicated alternate desktop themes, panels, or panel positions, but not extra panel widget*s or desktop wid*gets.

5.1.4.3 Response Quality and Validation

Several guidelines were used to validate the collected data.

Responses with no screenshot and insufficient notification description were discarded. Responses with a screenshot and insufficient notification description were discarded. Responses that were obvious repeats (either by accident because of session caching or on purpose), the least complete response was discarded. Responses that were not in English were discarded.

Responses with no screenshot but a sufficient notification description were not discarded. Responses that had incomplete user details but had sufficient notification description were not discarded. This often resulted in partially incomplete reports that had sufficient detail to be useful to the study.

English Language Proficiency (Q15) was originally meant to filter out participants in which English was a second (or third) language and who may not have understood the instructions. However, even those who marked the lowest level of English language skills provided well-formed responses (a contrast to what Americans would consider "little" proficiency in a second language).

A total of 239 responses were collected and four responses were discarded for a final total of 235 valid responses.

5.2 User Interviews

After the design of the preliminary conceptual model, interviews were conducted with additional KDE community members. The focus of the interviews was on KDE developers as the knowledge workers of the community, but several non-developers were also interviewed. The purpose of the interviews was to confirm or contradict findings from the UXR and offer an alternate format for additional exploration of major themes.

5.2.1 Participants

Developers were targeted in the Interviews as a way of exploring knowledge working in depth. Participants were recruited from known contacts within the community and in IRC channels in which KDE developers frequented. Participants in the UXR had been asked to indicate if they would be interested in participating in follow-up interviews. However, I did not take advantage of those participants. Instead, I felt that I would get better recruitment of the knowledge workers (developers) I wanted to interview by personally recruiting participants on IRC. Requests for interviews were made in

developer-oriented IRC channels. Several participants were referred to by personal contacts and interview participants. I did not ask if participants had previously participated in the UXR study. Participants were compensated by a €5 donation to the KDE e.V. in their name.

5.2.2 Instrument

Interviews were conducted using a semi-structured format with interview questions guiding open-ended responses and the possibility for follow-up questions and open discussion. The following is a list of interview topics with an extended list of questions in Appendix 7:

- Social Context of Notifications
- Task Management
- Action Buttons on Notifications
- Notification UX
- Music Players
- Environment
- Closing

While the structure and key interview questions were the same, the content or flow of the interviews may differ depending on the individual participant's experiences.

5.2.3 Procedure

At the beginning of the interview, participants were directed to a web-based survey which administered the IRB consent and collected participant demographics (see Appendix 6). Once participants completed the survey, they returned to the interview

and the interview was conducted. Depending on the flow of the interview, all of the questions may or may not have been covered. At the end of the interview, participants were given an opportunity to add any additional comments before the interview ended. Interviews were conducted over IRC (chat) and lasted from 30-60 minutes.

I chose to conduct the interviews over IRC for three reasons. First, IRC is the primary real-time collaboration medium for the KDE community and KDE contributors. KDE developers are comfortable with communicating over IRC. Second, English was a second language for most of the participants. Even though participants had good English language skills, they are most practiced at reading and writing English than speaking English. Therefore IRC was the best medium to communicate with these participants. Third, IRC provided an easy way to obtain interview transcripts. Transcripts are better to analyze than interview notes because they provide a literal account of what happened during the interview.

Interviews were conducted until I felt I had reached theoretical saturation after 14 interviews, that is nothing new was being learned for the amount of research being done (diminishing returns).

5.2.4 Data Analysis

Interview transcripts were analyzed using a qualitative approach. Unlike the UXR study, this data was not analyzed using a Grounded Theory approach, but instead was analyzed for the purpose of confirming or contradicting findings from the UXR. The results of the Interview coding were compared to the UXR results to provide confirming or contradicting evidence to the major UXR themes.

Axial coding was conducted within the major UXR themes (see section on UXR Data Analysis), influenced by the purpose of looking for confirming and contradicting evidence. Coding was iterative with several passes through the data to ensure even coding. Two researchers (myself and Anita Komlodi) each coded 100% of the interviews. The two researchers discussed the common and differing codes and made adjustments where necessary.

Additionally, Open Coding was conducted on the interview comments related to the two questions that asked participants to list their top five likes and dislikes. While there were opinions expressed throughout the interviews of things participants liked and disliked, the purpose of these questions was to help participants prioritize the most important comments. Coding was iterative with several passes through the data to ensure even coding. One researcher (myself) coded 100% of the interviews while one researcher (Anita Komlodi) coded 100% of the interviews. The following is a list of codes generated from the open coding analysis of the Interview likes and dislikes:

- Application Support
- Configuration and Integration
- Notification and Information Management
- Types of Interactions
- Visual Design Elements
- General Comments

5.3 Models of Influential Contextual Factors

Models were developed that described how the contextual factors found in this research affected the notification user experience. These models were derived from results of the qualitative and quantitative analysis. Models were created by analyzing the significant statistical relationships and major grounded theory themes. The findings were categorized into the dimensions of user experience context as a way of making sense how the contextual factors influenced the overall user experience. These combinations of contextual factors were documented in tables, mapped based on the user experience context dimensions, and illustrated through individual influence models.

Influence was defined from the user experience measurements of emotion and future use. An influence was positive if emotion was positive and/or future use was yes. An influence was negative if emotion was negative and/or future use was no. An influence was mixed if it could be positive or negative depending on the situation or combination of contextual factors. For example, experiences that were highly variable positive or negative were documented as mixed experiences. Values for emotion and future came from the qualitative and quantitative data and analysis.

High-level maps were created to document the interactions and influences between contextual factors. Each map focuses on a single dimension of the notification user experience context and shows how different contextual factors influence the user experience. Then, a series of simplified models, organized based on the dimensions of the notification user experience context, were created to document individual

influences. References to the evidence in support of the maps and models are also provided.

5.4 System Design Guidelines

Design guidelines were developed based on the results of the UXR study, Interviews, and notification UX models. In general, there are two types of design guidelines:

- **Explicit rules that specify certain user interface features or software behaviors.** These rules are often derived from research, usability testing, or from industry standards and best practices. (e.g., Apple's Human Interface Guidelines (Apple, Inc. 2011))
- **Heuristics that guide design decision making.** These heuristics are often derived from guiding theories and principles that have been demonstrated in similar applications to work. (e.g, Jakob Nielsen's 10 Usability Heuristics (Nielsen and Molich 1990))

The notification user experience guidelines developed from this research are heuristic in nature and provide general principles to guide design decisions. The heuristic guideline approach was chosen to allow the guidelines to be generalizable beyond the KDE notification system.

Chapter 6: Results

This chapter describes the results of the described research activities. First, descriptive information about the User Experience Reports (UXR) responses is cataloged in the context of the User Experience (UX) Dimensions presented in the Statement of Research. This information provides a list of contextual factors that were derived from this research and used in the qualitative and quantitative analysis. Next, summary participant demographic information from the Interviews is provided.

The rest of the chapter describes results from the analysis of the UXR (qualitative and quantitative) and Interviews. Results are reported mixed together to provide a cohesive context. Major findings are organized into themes with related summary analysis, statistics, and participant quotes. Although it is more common to report qualitative and quantitative results separately, I felt that some level of context was needed to present the volume and complexity of the results. Note that I only report on the interesting relationships and not expected obvious relationships. Participant quotes from each of the studies are marked as (UXR) from the user experience reports and (INT) from the interviews.

6.1 Descriptive Study Information

6.1.1 UXR Response Summary

A total of 235 valid responses were collected in the UXR study over a period of six weeks. Participants were not required to answer any questions, but only responses

that met the requirements described in the Methodology section were retained and analyzed. Note that because of this, some questions have fewer responses than 235.

In addition to survey responses, many questions included open text areas to provide an area for participants to explain or elaborate.

6.1.1.1 Gender

Generally speaking, there was an overwhelming number of male participants and under representation of female participants. However, the ratio of female participants is normal for the population studied (as discussed in the Methodology). Table 10 provides the ratio of male and female UXR participants.

Male	Female	Total
215	7	222

Table 10: Ratio of male and female UXR participants

6.1.1.2 Age

The study population had a strong representation of young participants that is typical of most open source projects, especially KDE. Most participants were between the ages of 25 and 34 years. Table 11 provides the distribution of ages among UXR participants.

18-24	25-34	35-44	45-54	55-64	65	Total
64	112	31	13	3	0	223

Table 11: Age distribution of UXR participants

6.1.1.3 Education

There was a wide variety of education experience represented by the study population, ranging from High School education to Graduate-level education. Most

participants had a College or Graduate-level education. Table 12 provides the distribution of education levels among UXR participants.

High School	Some College	College	Graduate	Total
38	34	79	71	222

Table 12: Education distribution of UXR participants

6.1.1.4 Occupation

The population occupation was dominated by the technology field, either through education or employment. Most participants were software developers or students. Table 13 provides a list of the top five occupations of UXR participants.

Software Developer	65
Student	59
Academic/Researcher	15
Engineer (Probably software-related)	8
Technology (non-Software)	7

Table 13: Top 5 UXR participant occupations

6.1.1.5 Country

The KDE community is a very international project with contributors on nearly every continent. The study population reflects this with similar levels of international participation, primarily in Europe and the Americas. Table 14 provides a list of the top five UXR participant countries. Most participants were German, which makes sense since KDE is a German-founded project. Figure 8 provides a map that shows the distribution of participants throughout the world (the pins indicate represented cities and not the total number of participants).

Germany	46
Spain	23
United States	23
Argentina	12
United Kingdom	10

Table 14: Top 5 UXR participant countries

Figure 8: Map of participant cities represented in the KDE User Experience Report study

6.1.1.6 English Language Proficiency

English language proficiency was scored because the study targeted an international, multilingual population and the instrument was written in English. This measure was originally meant to filter out participants who may not have understood the instructions. Most participants were fluent in English. However, even those who marked Little English language skills had well-formed responses (a contrast to what Americans would consider “little” experience of another language). Only responses that were not in English were discarded. Table 15 provides a distribution of English language proficiency of UXR participants.

Little English	Tourist-Level	Fluent	Native Speaker	Total
11	66	111	37	225

Table 15: Distribution of English Language Proficiency of UXR participants

6.1.1.7 Role in KDE

There are many roles within the KDE community. Some people develop code while other people contribute in other ways (such as translations or user interface design). Users can sometimes become supporters of KDE by providing a monetary donation or actively promoting and evangelizing the project. Sometimes participants were more than one, such as a Developer and a Supporter. Most participants in the UXR study were Users. Table 16 provides a distribution of KDE roles. These numbers do not add up to the total number of responses because participants could indicate they belonged to more than one of these groups.

Developer	Contributor	Supporter	User
19	34	38	209

Table 16: Distribution of KDE roles of UXR participants

A post-hoc distinction between all contributors (Developers and Contributors) and non-contributors (Supporters and Users) was also made (Table 17).

KDE Contributor	Not a KDE Contributor	Total
49	175	224

Table 17: Distribution of KDE Contributors of UXR participants

6.1.1.8 Stop Task to Respond to Notification

Participants were asked if they stopped their task in order to respond to the notification (Q7: Did you stop what you were doing at the time of the notification?). Most participants did not stop their task. Table 18 provides a distribution of the participants who stopped their task. In some cases, participants explained that they didn't always need to stop, that is, the notification did not require a response.

Stopped Task	Did Not Stop Task	Total
98	128	226

Table 18: Distribution of UXR participants who stopped their task due to a notification

6.1.1.9 Notification Related to Current Task

Participants were also asked if the notification they were reporting on was related to the task it interrupted (Q8: Was the notification related to the task it interrupted?). In most cases the notification was not related to the current task. Table 19 provides a distribution of notifications that were related to the participant's task.

Related to Task	Not Related to Task	Total
46	177	223

Table 19: Distribution of notifications that were related to the participant's task

6.1.1.10 Type of Computer

Participants were asked what type of computer they were reporting the notification user experience report from. The number of participants who used Desktops and Laptops was nearly equal. Table 20 provides a distribution of the types of computers used by UXR participants.

Desktop	Laptop	Tablet	Phone	Total
109	116	0	0	225

Table 20: Distribution of types of computers used by UXR participants

6.1.1.11 Use of Computer

Participants were also asked in what type of working environment they were reporting from. Most participants participated while they were at home. Table 21 provides a distribution of environment locations.

Home	Work from Home	Work	School	Other	Total
128	47	35	3	12	225

Table 21: Distribution of environment locations of UXR participants

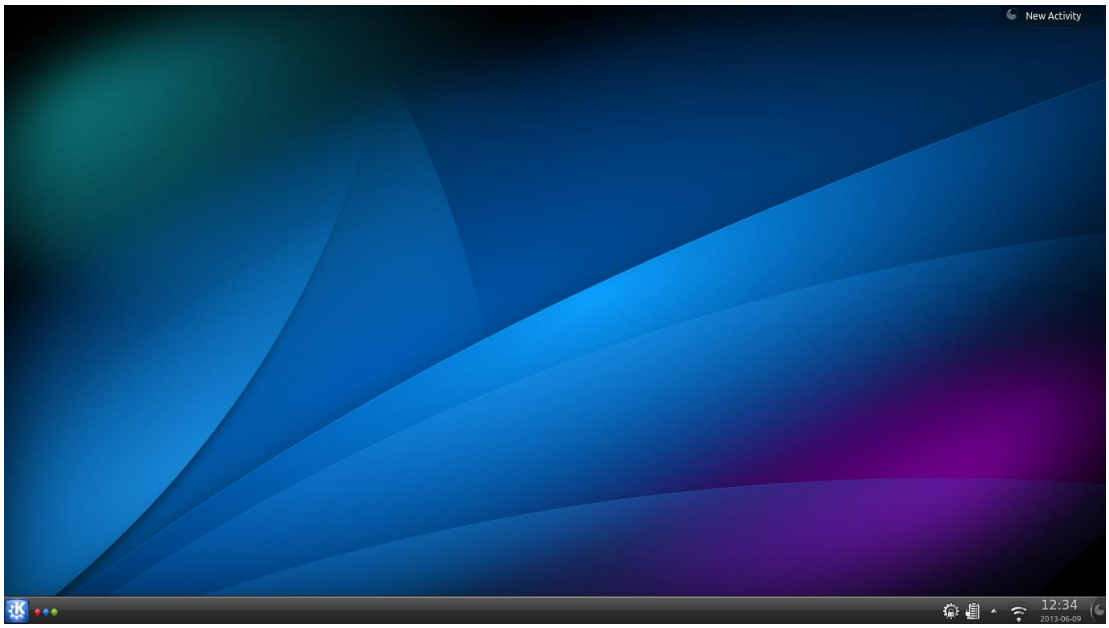
A post-hoc distinction between participants who were working (Working, Working from Home) and not working (Home, School, does NOT include Other since the context cannot be established) was made. Most participants were not in a working role. Table 22 provides a distribution of working roles.

Working	Not Working	Total
82	131	213

Table 22: Distribution of working roles of UXR participants

6.1.1.12 KDE Desktop Layout

Participants were asked to provide screenshots of their desktops near the time of the notification in order to help understand their computer environment. A post-hoc analysis of the screenshots determined if participants were using a layout close to the default KDE desktop layout, or a highly customized layout (Figure 9).



A) Default KDE Desktop Layout

B) Example Custom KDE Desktop Layout

Figure 9: Sample KDE Desktop Layouts. A) Default KDE Layout; B) Example KDE Custom Layout

The desktop layout was of interest because a customized layout may indicate non-standard display of notifications or a tendency for the participant to customize other aspects of their environment. Most participants were not using the default desktop layout. Table 23 provides a distribution of default and not default desktop layouts among UXR participants.

Default Layout	Not Default Layout	Total
57	95	152

Table 23: Distribution of desktop layout of UXR participants

6.1.1.13 Notification Socialness

Notification socialness was a measure of the social purpose of a notification. The socialness of the notification was derived from the analysis of Q2: What was the notification about? and Q3: What service or application sent the notification? If the purpose of the notification was to support communication or collaboration with another person, then it was **social**. For example, a notification that is an invitation to

chat is social. If the purpose of the notification did not support communication or collaboration with another person, then it was **not social**. For example, a notification that is about a failed connection to an email server is not social. Most notifications reported by participants were not social. Table 24 provides a distribution of social notifications.

Social Notifications	Not Social Notifications	Total
54	181	235

Table 24: Distribution of social notifications of UXR participants

6.1.1.14 Want Similar Future Notifications

Participants were asked if they would want a notification again in the future was a way of identifying desirable (or non-desirable) notifications and explore important factors. The responses came from Q4: Would you want a notification like this again in the future? Participants were not forced into a "yes" or "no" answer, and could respond "it depends" and explain if necessary. Most participants responded that they would like similar future notifications. Table 25 provides a distribution of participants who wanted similar future notifications.

Yes Future	No Future	It Depends Future	Total
144	30	60	234

Table 25: Distribution of UXR participants who wanted similar future notifications

6.1.1.15 One Word Response Emotion

Participants were asked to describe their overall notification user experience with a one word response (OWR) (Q5: Using one word, how would you describe your overall notification user experience?). Many of these responses contained **positive** or **negative** emotional words. Most notifications were described using positive words. Table 26 provides a distribution of OWR emotional words.

Positive Words	Negative Words	Total
139	66	205

Table 26: Distribution of OWR emotional words

6.1.2 Interview Participants Summary

Follow-up interviews were conducted with 14 KDE developers, contributors, supporters and users to confirm/contradict findings from the UXR study as well as dig deeper into some of the major themes. Table 27 provides a summary of the interviewee participants. The interview participants consisted of more developers than the UXR as a way to explore the effects on knowledge workers.

Demographic	**Responses**	
Job Role/Title	Software developer/engineer (5) Student (4) Community manager (1) CTO (1) Information Technology (1) Office worker (1) Sales manager (1)	
Role in KDE	Developer (7) Contributor (7) Supporter (5) User (9)	KDE Contributor (12) Non-contributor (2)
Education	High school (1) Some college (3) College degree (6) Graduate degree (4)	
English Language Proficiency	Native speaker (7) Fluent (5) Conversational (2)	
Computer	Desktop (8) Laptop (6)	
Country	Denmark (2) Switzerland (2) United Kingdom (2) United States (2) Finland (1) Germany (1) Netherlands (1) Romania (1) Scotland (1) Spain (1)	

Gender	Male (14)
Age	18-24 (1) 25-34 (9) 35-44 (3) 45-54 (1)

Table 27: Interview participant demographics

6.2 Notification User Experience

6.2.1 One Word Response Emotional Words

Participants in the UXR were asked to describe their overall notification user experience using one word (one word response, OWR) (Q5). More responses were described using positive words (n=139) than negative words (n=66).

6.2.1.1 Positive Words

The most popular positive word reported in the UXR OWR used to describe the notification user experience was *good*. This word was also reported in the Exploratory Study, but was not as popular. Additional popular positive words in the UXR OWR were *OK*, *great*, *informative*, and *useful*. See Table 28 and Figure 10.

Positive Emotional Words							
Good	46	Fine	3	Correct	1	Opportune	1
OK	15	Nice	3	Easy	1	Practical	1
Great	7	Pleasant	2	Enlightened	1	Reasonable	1
Informative	5	Positive	2	Expected	1	Relief	1
Useful	5	Simple	2	Fair	1	Sharp	1
Awesome	4	Smooth	2	Fast	1	Shiny	1
Excellent	4	:)	1	Infrequent	1	Smart	1
Helpful	4	Acceptable	1	Like	1	Tolerable	1
Satisfactory	4	Accurate	1	Love	1	Unobtrusive	1
Cool	3	Brilliant	1	Moderate	1		
Decent	3	Convenient	1	Normal	1		

Table 28: Positive Emotion Words from UXR One Word Response (OWR)

Figure 10: Word cloud of top OWR positive words from UXR

6.2.1.2 Negative Words

The most popular negative word reported in the UXR OWR used to describe the notification user experience was *annoying*. This word was also the most popular word reported in the Exploratory Study. Additional popular negative words in the UXR OWR were *distracting*, *improvable*, and *poor*. See Table 29 and Figure 11.

Negative Emotional Words							
Annoying	11	Clunky	1	Hard to dismiss	1	Noisy	1
Distracting	4	Complicated	1	Hate	1	Overkill	1
Improvable	4	Confusing	1	Horrible	1	Overload	1
Poor	4	Could be better	1	Immature	1	Scattered	1
Bad	2	Cumbersome	1	Imperfect	1	Tedious	1
Cluttered	2	Disrupting	1	Incomplete	1	Too sudden	1
Useless	2	Dull	1	Inconsistent	1	Uncomfortable	1
Abysmal	1	Dumb	1	Irritating	1	Unfinished	1
Adequate	1	Flawed	1	Lacking	1	Unripe	1
Boring	1	Frustrating	1	Meh	1	Unsatisfying	1
Bothersome	1	Glitchy	1	Needless	1	Weak	1

Table 29: Negative Emotional Words from UXR One Word Response (OWR)

Figure 11: Word cloud of top OWR negative words from UXR

6.2.2 Significant Emotion and Future Relationships

The relationship between Future Use (UXR question Q4: Would you want a similar notification again in the future?) and Emotion (Q5: One Word Response) provided a meaningful measure of the user experience. There are a number of statistical relationships that provide validity to the use of Emotion and Future as a measure for user experience.

There was a significant relationship between wanting similar future notifications and the emotional tone of the word used to describe the reported notification experience. Participants who described their notification experiences with positive emotional words were likely to want similar future notifications (Table 30).

Future (All Responses) X One Word Response Emotion			
	OWR Emotion – Negative	*OWR Emotion – Positive*	*Total*
Future – It depends	21	26	47
Future – No	23	3	26
Future – Yes	22	110	132
Total	66	139	205
Chi-Square	DF=2	Value=55.644043	p<0.0001
Cramer's V	DF=2	r=0.52099	p<0.0001

Table 30: Future Notifications X OWR Emotion

Also, participants who described their notification experiences with negative emotional words were likely to not want similar future notifications (Table 31).

Future (Yes/No Responses Only) X One Word Response Emotion			
	OWR Emotion – Negative	*OWR Emotion – Positive*	*Total*
Future – No	23	3	26
Future – Yes	22	110	132
Total	45	113	158
Chi-Square	DF=1	Value=54.966774	p<0.0001
Cramer's V	DF=1	r=0.58982	p<0.0001

Table 31: Future Notifications (Y/N Only) X OWR Emotion

It makes sense that people who have a positive user experience would want to repeat that experience and would want to not repeat negative experiences.

As previously discussed, there is a strong relationship between wanting similar future notifications and the use of positive emotional words to describe the notification user experience.

Positive notification user experience (Yes Future + Positive OWR) were likely to exist in relationships with many of the major contextual factors: notification message socialness, notification message relatedness to task, working role, contributor role, and computer environment.

Negative notification user experience (No Future + Negative OWR) were likely to exist in fewer relationships such as with non-social notification messages, while participants were in a working user role, and if participants were using a laptop.

Participants who received non-social notification messages were likely to describe experiences they did not want again in the future with negative emotional words and experiences they did want again with positive emotional words (Table 32).

Non-Social Notification Messages			
	OWR Emotion – Negative	*OWR Emotion – Positive*	*Total*
Future – No	21	3	24
Future – Yes	17	83	100
Total	38	86	124
Chi-Square	DF=1	Value=45.261517	p<0.0001
Cramer's V	DF=1	r=0.60416	p<0.0001

Table 32: Future Notifications X OWR Emotion (Non-Social Notification Messages)

Participants who received social notification messages were likely to describe experiences they wanted again in the future with positive emotional words (Table 33).

Social Notification Message			
	OWR Emotion – Negative	*OWR Emotion – Positive*	*Total*
Future – No	2	0	2
Future – Yes	5	27	32
Total	7	27	34
Fisher's Exact Test	p=0.0042		
Cramer's V	DF=1	r=0.49099	p=0.0042

Table 33: Future Notifications X OWR Emotion (Social Notification messages)

Participants who did not stop their current task when they received a notification were likely to describe experiences they wanted again in the future with positive emotional words (Table 34).

Did Not Stop Current Task			
	OWR Emotion – Negative	*OWR Emotion – Positive*	*Total*
Future – No	13	3	16
Future – Yes	13	59	72
Total	26	62	88
Fisher's Exact Test	p<0.0001		
Cramer's V	DF=1	r=0.53422	p<0.0001

Table 34: Future Notifications X OWR Emotion (Did Not Stop Current Task)

Participants who stopped their current task when they received a notification were likely to describe experiences they wanted again in the future with positive emotional words, and, experiences they did not want again in the future with negative emotional words (Table 35).

Stopped Current Task			
	OWR Emotion – Negative	*OWR Emotion – Positive*	*Total*
Future – No	10	0	10
Future – Yes	8	45	53
Total	18	45	63
Fisher's Exact Test	p<0.0001		
Cramer's V	DF=1	r=0.6868	p<0.0001

Table 35: Future Notifications X OWR Emotion (Stopped Current Task)

Participants who were not working were likely to describe experiences they wanted again in the future with positive emotional words (Table 36).

Not Working			
	OWR Emotion – Negative	*OWR Emotion – Positive*	*Total*
Future – No	13	2	15
Future – Yes	14	61	75
Total	27	63	90
Fisher's Exact Test	p<0.0001		
Cramer's V	DF=1	r=0.55301	p<0.0001

Table 36: Future Notifications X OWR Emotion (Not Working)

Participants who were working were likely to describe experiences they wanted again in the future with positive emotional words, and experiences they did not want again in the future with negative words (Table 37).

Working			
	OWR Emotion – Negative	*OWR Emotion – Positive*	*Total*
Future – No	10	0	10
Future – Yes	7	37	44
Total	17	37	54
Fisher's Exact Test	p<0.0001		
Cramer's V	DF=1	r=0.70332	p<0.0001

Table 37: Future Notifications X OWR Emotion (Working)

Participants who used a desktop computer were likely to describe experiences they wanted again in the future with positive emotional words (Table 38).

Desktop Computer			
	OWR Emotion – Negative	*OWR Emotion – Positive*	*Total*
Future – No	9	1	10
Future – Yes	11	53	64
Total	20	54	74
Fisher's Exact Test	p<0.0001		
Cramer's V	DF=1	r=0.56051	p<0.0001

Table 38: Future Notifications X OWR Emotion (Desktop Computer)

Participants who used a laptop computer were likely to describe experiences they wanted again in the future with positive emotional words and experiences they did not want again in the future with negative emotional words (Table 39).

Laptop Computer			
	OWR Emotion – Negative	*OWR Emotion – Positive*	*Total*
Future – No	14	2	16
Future – Yes	10	51	61
Total	24	53	77
Fisher's Exact Test	p<0.0001		
Cramer's V	DF=1	r=0.62286	p<0.0001

Table 39: Future Notifications X OWR Emotion (Laptop Computer)

6.3 Notifications in the Social Context

One of the most important roles of interruptive notifications in the KDE environment was to support interaction and awareness of activity with other people.

6.3.1 Supporting Social Interactions

In general, social notifications provide updates of new information in a person's social context. This is similar to how notifications provide information awareness in other non-social contexts.

Knowing when a new email has arrived was an important type of awareness notification.

> "Its hard to live without notifications about incoming mails." (UXR#92)
>
> "I want to know when a new mail arrives." (UXR#99)
>
> "Sometimes I need to know an e-mail has arrived." (UXR#189)
>
> "I want to be informed when I get a new email." (UXR#213)

For some participants, it was just as important to know when there were new messages to microblogging services such as Twitter and Facebook.

> "I want to know how many unread messages there are before using Choqok [KDE's microblogging feed reader]. I like to know quickly how many unread messages I have on Twitter and identi.ca [an open source microblogging service similar to Twitter]." (UXR#159)

> "It is good to know when a new tweet arrives." (UXR#90)

Participants were especially interested when they were mentioned in social media.

> "If someone mentions me [in a tweet] a notification would be great." (UXR#174)

> “IRC name mentions are very important to me. I work from home and [me and my co-workers] talk over IRC so I need to be available in case they need me.” (INT#11)

However, a notification of new email or tweets was not always necessary. Eleven of 45 UXR responses regarding email indicated they did not want the notification again in the future and four of 14 interviewees explained that they disabled email notifications. The condition under which social notifications should or should not be sent was varied and will be explored in later sections.

> "I wasn't using my email at the time. I didn't need to know." (UXR#13)

> "I'd like to be notified about e-mail but the notification is quite cluttered with unnecessary detail." (UXR#55)

> "New tweets are not so important. I read new tweets regularly." (UXR#174)

> “Facebook updates I want to browse if I'm really bored but not have them sent to me directly.” (INT#4)

> “For me, [notifications are] important only in the case of emails, [instant messages] or IRC. No Facebook status updates or tweets or stuff like that.” (INT#13)

This was especially true for developers who tended to undervalue email and turned off email notifications. Perhaps this was because they received so many notifications due to subscribing to mailing lists, bug trackers, and software version control services. If something was important, chatting directly with a person was the way to go.

> “A lot of notifications I’ve simply turned off, such as the ‘email sent’ (really…) or the power management ones.” (INT#1)

> “New email is not really important but I’m used to it.” (INT#11)

> “An urgent [instant message] is generally more important than an urgent email.” (INT#10)

> “I don’t get [notifications] for email and I don’t use Twitter.” (INT#5)

> "[I only receive notifications] from [instant message]/chat-type apps. With more asynchronous media [e.g., email] I prefer to check manually." (INT#6)

Status notifications in social media (when a person comes online, goes away, is no longer away, etc.) were deemed not valuable by participants. Turning off status notifications was one of the most common notification system customizations.

> "I always close Skype down after use because of the constant 'so and so is now online' notifications" (INT#4)

> "Generally I want to see messages in notifications, but not activity. I hate seeing people online/offline, or playing songs etc., its just distracting." (INT#7)

12 of the 22 (UXR) KDE contributors who were responded while "working" were working from home. Notifications about direct communication requests from their social services (as opposed to simple status updates), such as Skype or IRC, were critical because these were the communication channels remote meetings took place. This was further explored in the interviews where three of the 14 participants worked from home.

> "I am sometimes expecting contact from someone at a given time and I keep an eye out for those notifications in particular." (INT#1)

6.3.2 Conversations with People

While social notifications were often discussed in a positive way, not all social notifications were equally regarded, as previously discussed. The most important

social notifications were those that supported direct communication: synchronous and ongoing conversations with people over chat. Participants wanted to chat with friends and colleagues and a notification is an invitation to do so.

> "I wanted the [chat] reply." (UXR#58)

> "I wanted to answer the chat message." (UXR#32)

Notifications help participants manage conversations.

> "It helps me know in short who is saying what to me and gives me the option to respond now or delay till later." (UXR#233)

Notifications support ongoing communication by letting users know when there is a new message to respond to.

> "It was an ongoing discussion on IRC where I waited for the person to come back to continue the discussion." (UXR#14)

Sometimes participants were busy at the time of the notification and wanted to wait until later to chat with a person. This was more common for participants who were not in a working environment.

> "It is not necessary that I will talk to the person who came just online." (UXR#202)

> "Because the text said in the IRC challenge was not urgent." (UXR#15)

Most often, participants described wanting to respond quickly to a social notification message that contained a request for direct communication/chat. There was a sense of

urgency to respond within a reasonable amount of time, especially when the flow of a conversation depended on their participation.

> "Because it is important to react fast to people sending me private notifications." (UXR#14)

> "I still listened to the talk, but I did reply to my conversation. Because conversations are streamlined and depend on my input." (UXR#62)

> "Because a web page can wait to be read, a real person might want an answer ASAP." (UXR#211)

> “IRC is more synchronous, with people expecting an answer within a minute or so. And it's where I do mentoring and support and so on, so it's important to be prompt. If someone is not able to respond quickly, there are often consequences.” (INT#2)

The urgency in which to respond was often a function of the importance of the current task and who is trying to have a conversation.

> “[How quickly I respond] is a combination of many factors, including what I'm interrupted in, the 'difficulty' of the reply and how important I think an immediate reply is for the person who contacts me.” (INT#3)

6.3.3 Prioritization of Social Notifications

There was a strong sense of hierarchy in terms of importance of social notifications. Not all social notifications were of equal importance or value.

> "I did not consider the e-mails important (I have several filters applied, and mails that get into my inbox unfiltered are usually not really important)." (UXR#55)

> "The email was important and I needed to reply to it ASAP." (UXR#63)

> “Mostly mail, Twitter, G+ and similar things can wait” (INT#2)

This prioritization was often tied to a person rather than the communication channel the message came from.

> “If it's my boss, or a colleague I know I need to get back to them quickly because of an in-flight task, or a close friend, I'll try to respond sooner rather than later.” (INT#6)

> “It is not important to know whether or not someone is online. But it is important to get notified when they want to interact with me.” (INT#3)

The information the notification provided was often a way for participants to prioritize within a social context.

> “The person is usually the most important, [but] the message is sometimes important (emergency type things)” (INT#1)

When opportunities to communicate with others arose, some people were more important than others.

> "There [are] people I care about and others I don't, so it is some kind of annoying to have ... 50 notifications, that I only care about 3 of them." (UXR#186)

> "[I did not respond because] the e-mail was not from any of my Facebook friends." (UXR#63)

> "[I did not respond] because the person [was not] important." (UXR#61)

> “I work from home for a software company and use KDE with [KDE chat application] in my work. If a workmate gives me an important message – that I want to respond to immediately. Alternatively, if I had Facebook/Google+ chat notifications and someone wanted to chat about something important or interesting, that also would be immediate.” (INT#7)

When participants were at work, their co-workers, clients, and other work related people were the most important people to respond to in a timely way.

> “In work hours when I'm not at the office, co-workers/boss are more important than others.” (INT#3)

This prioritization sometimes negatively affected the timeliness of response to non-work related communication.

> "[I did not respond because] It was a friend, not a colleague coming online and I was at work." (UXR#30)

Family members and close friends were often highly prioritized, even at work.

> "For me there is a group of people who are always important (family, in my case)." (INT#1)

6.3.4 Significant Socialness Relationships

There were several statistically significant relationships related to notification socialness that complement the qualitative analysis.

Participants who received a social notification message were likely to describe their notification experience with positive words if they were not working (Table 40). If a person was not working, they were often more available to chat with a friend than if they were working. However, there are some exceptions to this, such as if the social message is work-related. I will discuss this further in a later section.

Social Notification Messages			
	Not Working	*Working*	*Total*
Emotion – Negative	3	8	11
Emotion – Positive	21	9	30
Total	24	17	41
Fisher's Exact Test	p=0.0292		
Cramer's V	DF=1	r=38427	p=0.0139

Table 40: OWR Emotion X Work Role (Social Notification Messages)

6.4 Notifications in Support of Task Management

Task management, specifically with regards to multi-tasking or rapid task switching, was a common activity participants discussed when describing their notification user experiences (Q7 and Q8). The use of notifications to support task management was also explored during the interviews.

In general, participants liked how notifications supported task management.

> “For some cases, [notifications] support my workflow quite well.” (INT#2)

6.4.1 Task Overlapping

The task environment participants described often included "overlapping" tasks, that is, participants would have several unrelated tasks at different stages going on at the same time. Notifications helped participants manage multiple tasks or activities at the same time.

> "I have to be notified when a file operation finished. Meanwhile I can do other tasks." (UXR#205)

> "I don't have to keep an eye on one or more IRC channels and can do other stuff." (UXR#211)

> "Because with KDE's notifications you can do other things while processes are running or you have the information." (UXR#75)

> “I'll have a meeting lined up on [IRC] for a given time of the day, and the person is supposed to message me when they are ready. I'll keep busy doing other things until they ping me and when they do (which I notice via a notification somewhere) then I switch to the meeting.” (INT#1)

> “Sometimes during chat conversations with people who have long response times, I do something else while waiting for an answer.” (INT#3)

> “I click on the download, tell it where to save the file, do other stuff while the systray icon is showing the download. Then I get a notification saying it's done, meaning I'm ready to watch Game of Thrones.” (INT#4)

Sometimes overlapped tasks were purposeful planning for a future task or activity.

> "I started the operation in preparation for something I wanted to work on a bit later." (UXR#8)

In some cases, a continuous or dependent task (e.g., file download or code compiling) was often overlapped with a "filler" task the person would work on while waiting for the main task to complete. These filler tasks were often stand-alone activities of little consequence compared to the main task (e.g. reading a web page while downloading a file needed for the main task).

> "I was browsing in the meantime letting the files copy." (UXR#27)

> "Because I was making time surfing the net until the script finished." (UXR#197)

> "I ... browsed Reddit because I didn't want to start doing something more sophisticated that would keep me from finishing preparing the

> tea." (He was waiting for a timer notification indicating the tea was steeped.) (UXR#207)

Temporary switches of focus, such as to read the notification message, are not necessary true task switches. However, these types of notifications help plan tasks through the information they provide. Sometimes these notifications act as directives to new tasks or simply provide information about a change in a passive background process.

> "[Notifications] let me know when someone sends me a message and lets me read it without switching from what I'm currently working on." (UXR#3)

There were a few examples of true multi-tasking with a single activity or goal, (i.e., switching between related but different tasks that contribute to the same end goal.)

> "[The notification is] part of the flow in this case. I was chatting while waiting for a command output (network was slow), but I regard the chat and command as the same activity." (UXR#162)

> "[I was copying a] show that I wanted to watch while reading the website of said show." (UXR#176)

6.4.2 Task Switching Cues

Notifications support task management and multi-tasking by providing cues to users to indicate when they can switch to a new task. Task switching cues were a way for participants to maximize work efficiency. Rapid task switching was accomplished by

participants using notification cues to help signal when the participant can or should switch tasks.

Notifications can indicate when it is possible to switch to a new or ongoing task.

> "[Notifications] inform me at which point (time) I can start browsing, fetch e-mails, etc." (UXR#192)

> "It's useful to know when some job is finished so I can start another." (UXR#201)

> “I like being told 'this torrent is done' as then I can go and watch whatever I was downloading” (INT#1)

In the case of social notifications, the message (combined with who the sender is and the priority of that person) within the notification often provides the information necessary to determine if the participant should switch tasks.

> “I try to ignore my messaging apps while working, and those notifications let me know when I need to stop what I'm doing to take care of something.” (INT#1)

Notifications also provide a confirmation of a past action in case something unexpected happened and the participant must intervene.

> “[Receiving a confirmation notification is good] for every process I have started manually, that can easily fail and where I don’t see the result directly (a login process wouldn’t need it, as I directly see whether I’m logged in or not).” (UXR#224)

While a task is ongoing, participants might check the task progress indicator (part of the notification system) to know when to expect a notification and to help with planning their next tasks.

> “I wanted to check the speed [of the download] and look at the notification.” (UXR#35)

6.4.3 Task Prioritization

Sometimes participants had to negotiate or prioritize the importance of the current task and the notification task. Notifications helped participants prioritize which task to attend to immediately or later.

> "[I] use many programs at once and use the notifications to alert the most relevant of my applications. Since I can only address [one] application [at a time]." (UXR#87)

> “[The notification] helps me know in short who is saying what to me and gives me the option to respond now or delay till later.” (UXR#233)

Sometimes the task indicated by the notification could be delayed or attended to at a later time.

> “Security updates I'll care about but not right away.” (INT#4)

Priority was a combination of multiple factors – what the person was doing, what the notification was about, how important either activity was – that helped participants decide if they should attend to the notification or wait until later.

> “It's useful to me when notifications carry some information about the origin (e.g. the name of the person trying to reach me) so I can decide whether it's worth interrupting my current activity (i.e. reacting to the notification by switching to the app where I can fold-up or see the entire conversation)” (INT#6)

Few notifications that needed a response were completely ignored. Notification tasks were likely to be lower priority than the current task and responded to at a later time—unless the notification is about the "real" main task and the current task is a "filler" task.

> “I didn’t have to stop, I got notified about the things I might have to pay attention to (I’m specifically talking about the battery getting low), took it in consideration, keeping it in mind that soon I’ll have to act on some of the notifications to be able to keep doing what I am doing.” (UXR#171)

6.4.4 Task Disruptions

While many participants experienced constant and regular interruptions, few were actual disruptions to their tasks. Good notifications had some purpose or use, even if it was lower priority than the current task, because they helped support awareness of other services.

> “[If I didn't have a notification] I would need to check the application always... and thus I'd need to interrupt my work regularly.” (INT#5)

However, some heavy multi-taskers (usually software developers) discussed how interruptions unrelated to their current task did affect their work.

> "After muttering under my breath about how I hate being interrupted all the time... then I usually put aside what I'm doing and move my attention to the communication. That I don't have a very good workflow now. Usually I just abandon what I'm doing temporarily and hope I'll come back to it eventually." (INT#1)

Some participants gave examples of notifications that fell in the middle of the urgent-to-ignore scale and dealt with them by first stabilizing their task before switching at their convenience.

> "There's that valley between the high urgency [contacts] and the interesting-because-they-are-unexpected [contacts] – anything that falls in between those peaks I might let sit for a while if I, say, want to finish writing something down or thinking something through first." (INT#6)

Although less common, there were cases in which participants received a notification at such a bad time that it was more than an interruption, but became a disruption. The low occurrence of these types of experiences may have been a sampling bias; participants who experienced a disruption may have been so overwhelmed that they did not want to or forgot to participate in the study for that particular notification event.

"When I'm working on something, or reading something important that requires attention - no I don't want the notification." (UXR#44)

"If I'm showing an Impress [open source PowerPoint] presentation I wouldn't like it." (UXR#53)

"Usually it's helpful knowing that everything I was waiting for to download has arrived. This time I was recording a video interview at the time, so it was *not* helpful." (UXR#88)

6.4.5 Significant Task Management Relationships

There were several statistically significant relationships related to task management that complement the qualitative analysis.

Participants who described their notification experiences with negative words were likely to have received a social message not related to their current task. They were also likely to describe their notification experiences with negative words for non-social messages not related to their current task (Table 41).

OWR Negative Emotion			
	Related to Task – No	*Related to Task – Yes*	*Total*
Social Message – No	38	13	51
Social Message – Yes	13	0	13
Total	51	13	64
Fisher's Exact Test	p=0.054* (2-tail); p=0.03625 (1-tail)		
Cramer's V	DF=1	r=0.2549	p=0.0414

Table 41: Socialness X Related to Task (OWR Negative Emotion)

Participants who stopped their current task were likely to have received a non-social message on a Laptop computer (Table 42). These notifications might have been

urgent system notifications (such as network or battery status) which are more likely to occur on a laptop computer.

Stopped Current Task			
	Desktop	*Laptop*	*Total*
Social message – No	26	44	70
Social message – Yes	16	11	27
Total	42	55	97
Chi-Square	DF=1	Value=3.8819551	p=0.0488
Cramer's V	DF=1	r=0.20005	p=0.0488

Table 42: Socialness X Computer (Stopped Current Task)

6.5 User Role and Environment

As discussed throughout these results, the role and environment of the user influenced how they experienced notifications. The most influential role was whether or not someone was a KDE contributor (developer or non-coding contributor). The most influential environment was whether or not they were working (at home or in the office). Eighty-five participants in the UXR responded while working. Twelve of 22 (UXR) KDE contributors who were working were working from home.

If participants were working, they wanted to do work things and talk to work people.

> "When I'm on call for technical support, the clients are more important to attend to. They usually get priority." (INT#13)

If participants were students, they were concerned about studying and interruptions.

> "Sometimes I don't want to receive a notification, like when I'm studying." (UXR#41)

KDE contributors who were developers cared more about notifications from chat, voice calls, and IRC and sometimes email. Non-developers cared about all types of social notifications.

> "The other day I received some news from [a supplier] and there was a problem. So I got a notification from Skype about this and I had to deal with it so we could make a decision on how to proceed." (INT#1, KDE developer)

> "It is good to know when a new tweet arrives." (UXR#90, Non-developer)

Developers also cared more about security-related updates while general users liked to receive all software updates. Software updates are not unimportant, just less important. This is likely because developers work in a custom environment so they need complete control over and require certain versions of software in order to write code. Security updates are often critical patches, and so are exceptions to this rule.

> "Security updates mostly make sense, notification bout new version not so much." (UXR#217)

> "I always if possible respond to security updates immediately… other updates I generally try to get to if I have time or not, but not always." (INT#7)

> "Security updates I'll care about but not right away. [More so than a general software update]" (INT#4)

6.5.1 Significant Work Role Relationships

There were several statistically significant relationships related to participant work role that complement the qualitative analysis.

Participants who were not in a working role were likely to want similar social notification messages again in the future (Table 43). Participants not working were also likely to describe social message experience with positive words (Table 44). Participants who were not working were more forgiving of notifications in general and liked receiving most types of social notifications while participants who were working had very specific preferences for social messages.

Not Working			
	Future – No	*Future – Yes*	*Total*
Social Message – No	17	62	79
Social Message – Yes	0	21	21
Total	17	83	100
Fisher's Exact Test	p=0.0196		
Cramer's V	DF=1	r=0.23334	p=0.0196

Table 43: Socialness X Future Notifications (Not Working)

Not Working			
	OWR Emotion – Negative	*OWR Emotion – Positive*	*Total*
Social Message – No	35	58	93
Social Message – Yes	3	21	24
Total	38	79	117
Chi-Square	DF=1	Value=5.4954934	p=0.0191
Cramer's V	DF=1	r=0.21673	p=0.0191

Table 44: Socialness X OWR Emotion (Not Working)

Participants who described their notification experiences with negative words were likely to have received non-social notification messages while not working (Table 45).

OWR Negative Emotion			
	Not Working	*Working*	*Total*
Social Message – No	35	17	52
Social Message – Yes	3	8	11
Total	38	25	63
Fisher's Exact Test	p=0.0193		
Cramer's V	DF=1	r=0.31065	p=0.0137

Table 45: Socialness X Working (OWR Negative Emotion)

Participants who were not working were likely to describe notifications they received when they did not stop their current task with positive words (Table 46). Participants who indicated they wanted a similar future notification were likely to have received a notification not related to their task while not working (Table 47).That is, while not working, if the notification was not interesting, urgent, or important enough to switch tasks to and they could continue what they were doing, participants had a positive notification experience.

Not Working			
	Stop Current Task – No	*Stop Current Task – Yes*	*Total*
OWR Emotion – Negative	18	20	38
OWR Emotion – Positive	53	26	79
Total	71	46	117
Chi-Square	DF=1	Value=4.182177	p=0.0409
Cramer's V	DF=1	r=0.18906	p=0.0409

Table 46: OWR Emotion X Stop Current Task (Not Working)

Do Want Future Notifications (YN Only)			
	Not Working	*Working*	*Total*
Related to Task – No	70	34	104
Related to Task – Yes	12	14	26
Total	82	48	130
Chi-Square	DF=1	Value=3.996443	p=0.0456
Cramer's V	DF=1	r=0.17533	p=0.0456

Table 47: Related to Task X Working (Do Want Future Notifications Y/N Only)

6.5.2 Significant KDE Contributor Relationships

There were several statistically significant relationships related to the participant role of being a KDE contributor that complement the qualitative analysis.

Participants who were KDE contributors were likely to have received non-social messages on a Laptop and social messages on a Desktop (Table 48). Perhaps this was because laptops provided mobility to "hide and code" while desktop computers tied them to a collaborative office environment.

KDE Contributor			
	Desktop	*Laptop*	*Total*
Social message – No	12	25	37
Social message – Yes	8	4	12
Total	20	29	49
Fisher's Exact Test	p=0.048		
Cramer's V	DF=1	r=0.29953	p=0.036

Table 48: Socialness X Computer (KDE Contributor)

Participants who were not KDE contributors were likely to want similar social and non-social notification messages again in the future (Table 49). Perhaps this is a reflection from the qualitative analysis that showed how non-developers tended to like all types of social notifications while developers tended to like only chat-related and email notifications.

Not KDE Contributors			
	Future – No	*Future – Yes*	*Total*
Social Message – No	20	79	99
Social Message – Yes	1	28	29
Total	21	107	128
Fisher's Exact Test	p=0.043		
Cramer's V	DF=1	r=0.18938	p=0.032

Table 49: Socialness X Future Notifications (Not KDE Contributors)

6.6 KDE Notifications

There were many types of notifications described by participants in the UXR. Table 50 provides a list of the most common sources of notifications.

Notification Source	Total
Email	45
File Management	39
Chat	33
Music	33
KDE/Operating System	29
Package Management	20
Microblogging	14

Table 50: Most common sources of UXR notifications

The most common type of notification were those from email services (n=45), such as notifications of new incoming email, confirmation of successfully sending an email, and errors connecting to an email server. KMail (KDE's email client) and Thunderbird (Mozilla's email client) were the most common email clients. KDE also includes a widget that connects to web-based email, such as Gmail, that will produce notifications for new email. Only one participant in the UXR mentioned receiving a notification from the Gmail widget, although several participants in the UXR and

Interviews described using web-based email clients which did not produce email-related notifications.

Another common type of notification were those regarding file management (n=39). Most of these notifications were regarding file download completions. A few notifications were about activity on remote file storage, such as DropBox or OwnCloud (n=3) and activity on KTorrent (KDE's peer-to-peer file sharing application, n=3).

Additional common sources of notifications included those from chat (n=33) and music (n=33) applications, KDE and general operating system (n=29), package management (software updates and downloads) (n=20), and microblogging applications that manage Twitter and Facebook (n=14).

Then, the Interviews provided an opportunity to go into detail with knowledge workers as to what and how various notification behavior, information, and user interface elements affected their user experience.

6.6.1 Visual Design

There were mixed feeling about the visual design of the KDE notification system. Many participants liked the visual design and felt it fit with the rest of the desktop look and feel.

> "I like that the notifications visually look like they fit in with the rest of the desktop." (INT#3)

Participants especially liked that they could configure the location of notifications, sometimes an issue for people who don't like their applications obscured by popups.

> "I like that [notifications] are all in one place, and that I can choose where that place is." (INT#1)

> "I like that I can move the notifications to whatever part of the desktop." (INT#7)

But others felt that there was more that could be done to make the notification system more attractive.

> "There's a general lack of UI polish in the notification system, that's the biggie – the layout of the individual notification items is poor at times (e.g. the way expanding copy job notifications into their detailed versions is implemented, with that forlorn-looking + button somewhere in the middle), stuff resizes at wonky times, the scrollbar gets misrendered at times, some elements are badly aligned, the "Respond" buttons on the KDE Telepathy chat notifications don't actually work half the time…" (INT#6)

When a relevant notification was displayed, there was no linking between the notification and the relevant application icon. Many notifications came from applications that also had a systray icon (such as an email icon that acted as a new message indicator and shortcut to the email program).

> "I wish the notifications were visually linked into the systray (if appropriate)." (INT#4)

Although the location of notifications could be configured, it was linked to where the notification widget was plays on the systray. Sometimes this location was not convenient and caused layout problems for some participants.

> "The notifications are fairly high [big] and that overlaps with useful screen space where my app is." (INT#2)

> "I would like to be able to position the notifications, I have my panel on the left edge of the screen with the systray in the top left corner, often the notifications pop ups "block" main toolbars of the windows I'm working with, so I would like to be able to have the notifications e.g. top right, even if the systray is top left." (INT#8)

The obscuring of information (also discussed in Interacting with Notifications) was perhaps the most common complaint about the design and interaction of the notification system.

6.6.2 Music Players

Notifications related to music players had the most diversity in terms of user acceptance. Many participants liked music players because they provided a way to learn the artist and titles of new songs and easily skip to the next track.

> "[I use music player notifications] only because it lets me skip to the next song if I don't like it" (INT#1)

> "When I listen to internet radio sometimes the track change notifications from the audio player is interesting to know what artist/song is up" (INT#6)

However, equally as many participants felt like these notifications were useless and had no value.

> “I mean, if the music stops, I'm bound to notice.” (INT#2)

> “I don't have music notifications turned on, that would be most annoying. I know what I'm listening to because I'm listening to it.” (INT#4)

Notifications from music players were one of the most common type of notification system customization mentioned, usually to turn them off.

6.6.3 Frequency of Notifications

The most common complaint about the KDE notification user experience was the number of repetitive notifications that were essentially the same or similar messages (n=10). This behavior ranged greatly, from related but unaware notifications that would be better designed if they were together, to simply bad behavior of continuously repetitive notifications from the same source.

> "[The notification] was useful here as I was genuinely interested in when the download was complete. However most KIO jobs I would not need a separate notification for." (UXR#17)

> "You can see several notifications showing the same information repeatedly. They could have been merged into one." (UXR#132)

> "If I get it for the first or the second time, it is OK. After that I learn this behavior of the program and the notification becomes excessive. Starts to annoy." (UXR#182)

> "Because it is totally useless as when I check mail for local mail folder it should not do anything and getting 14 times the same message in one check does not help either." (UXR#133)

Participants were happy with receiving these notifications the first time, but wanted following related messages combined or suppressed.

> "If a notification represents the first chat message in a conversation, I will like to see this type of notification." (UXR#34)

> "If messages are from the same person, I don't like them being cascaded." (UXR#154)

6.6.4 Timeliness of Notifications

Notifications and progress indicators were useful for helping participants plan activities and multi-task. This was especially true for activities that took a long time. However, many participants felt some notifications were unnecessary for activities that they still had in focus and only took a short period of time.

> "For long copyings it is nice, but I get annoyed when I constantly get these notifications for small copyings (e.g. while editing a remote file in KWrite and saving)." (UXR#8)

"For small files it doesn't make sense, only files that will take some time." (UXR#35)

"This notification should only appear if I am not looking to Konsole [command line interface] and the script has taken a long time to finish." (UXR#197)

6.6.5 Meaningful Notifications

Another common complaint about the KDE notification user experience was the number of messages confirming expected behavior. Participants were more interested in being notified of unexpected behavior especially if it was about something urgent or critical.

"It's a tad over the top to tell me a mail was sent. Tell me if it wasn't..." (UXR#19)

“If I send a mail, I only expect a notification on failure, not on success.” (UXR#219)

"[The notification was useless], I already know if it's paused, I paused it and can hear the music stop." (UXR#105)

"I don't need information that something was successful, in this particular case it's not an important message, error would be important." (UXR#130)

"Because I can fairly well see that it resumed, because I'm not blind and I had to hit a button or close the lid for it to suspend." (UXR#168)

6.6.6 Misplaced Focus by Notification

Related to context, there were a few cases in which participants received notifications for tasks or activities they were not currently engaged with, and so they were not necessary.

> "I wasn't using my email at the time. I didn't need to know." (UXR#13)

> "Useful when Dolphin [file manager] is in the background or closed." (In this case it was open and in focus) (UXR#153)

> "It was an after-the-fact type of notification." (UXR#116)

> "When the music player window is open on the same screen, the notification [about the music player] is not interesting." (UXR#212)

> "I'm not using KMail or other mail clients (I just use the GMail web client) so a message [from the mail service] would be useful only if I were using a mail client." (UXR#215)

6.6.7 Interacting with and Responding to Notifications

Many participants liked that notifications were interactive.

> “I like that one can interact with the notifications [KDE] provide.” (INT#3)

The types of interactions varied. The most common was the ability to click on a notification to get more information or react to a notification.

> “[I like the] respond button on a chat popup.” (INT#4)

Participants also liked the ability to click away notifications instead of waiting for them to disappear on their own.

> "[Notifications] are easy enough to click away." (INT#2)

> "I also like that I can dismiss all notifications from a button." (INT#13)

There were differing opinions on what the default action for clicking on the notification should be. Some participants wanted notifications to be interaction "transparent" and be able to interact with the application beneath the notification it may be covering.

> "I want to be able to 'click through' the notification so I can interact with the apps below" (INT#10)

However, other participants wanted interaction with a notification to keep it from disappearing.

> "If I hover the mouse over a notification, it shouldn't disappear until I remove the mouse." (INT#13)

Some participants described liking the notifications from new chat messages, especially the action button that helped them reply to the chat message. A few participants mentioned they would like having the ability to respond to a chat from the notification, instead of having to switch to the chat application.

> "I do wish that messaging notifications would give me the option of replying right from within the notifications." (INT#1)

> “[I want the] ability to quick reply from notifications. I would LOVE to be able to click reply and type [a response in the notification].” (INT#12)

Several participants described liking the ability to react to new notifications by clicking action buttons available in the popup user interface.

> “[The notification] is a good shortcut to the package manager” (UXR#82)

> “Because it is useful for unexperienced users (and for experienced users (who are able to mount manually) in everydays life, too!) to simply mount and access a portable device like usbstick, cd, dvd...” (UXR#190)

> “It provides quick access to the inserted device to choose an action” (UXR#6)

> “When I get a notification saying someone has said something [the notification] offers to take me to that window” (INT#1)

> “On the other hand, if Rhythmbox plays a song I don't quite like at the moment, I want to skip it by clicking "Next" in the notification” (UXR#44)

Action buttons on notifications were important to support seamless task-switching in a multi-tasking environment.

> “If I plugin something it's something I want to work with now, so it's supporting the task at hand” (INT#2)

Some notifications were well suited to have an action button (that is, had an obvious simple reaction to the type of message it provided) but did not provide one.

> “[If I receive an error notification] I don't have a direct way to fix the reported problem. When, for example, I get a message about the fact that I'm logged out, I need to search for the window to login [instead of just clicking the notification].” (INT#5)

However, there were plenty of things left to be desired about notification interaction. In a few cases, the notifications provided action buttons, but the buttons did not work, eliciting frustration from some participants.

> “Fix the action buttons! I like the action buttons, when they work.” (INT#7)

> “The 'Reply' buttons on [KDE chat application] don't actually work half the time” (INT#6)

> “I do use [the action buttons on notifications], even though they only work half the time. It really pisses me off, I love the action buttons.” (INT#7)

A few participants also discussed not using the action buttons on the notifications, not because they didn't like them, but habit led them to use the keyboard to switch to the relevant window.

> "If I already have a window open, muscle memory makes me just switch to it via the task bar." (INT#6)

6.6.8 Notification Information Management

One of the strengths of KDE's integrated notification system is that all notifications get sent through the same service and can be easily managed. This provides the notification system an ability to manage information and enhance the notification user experience.

For example, several participants liked that recent notifications are provided in an organized list that can be checked in case a notification was missed.

> "I like being able to have one place to click and view past notifications." (INT#12)

> "I like a way to list recent notifications." (INT#2)

> "I like that notifications are grouped by application/type if I have a number of them waiting for me." (INT#1)

> "I like the ability to get [notifications] back if I missed them." (INT#5)

> "I like that I can see [the notification] again and again. It doesn't go away once opened. For me this is good." (INT#13)

Most notifications also have a way of going away on their own.

> "I like that notifications expire. They disappear on their own." (INT#13)

However, some notifications need to be better configured to disappear on their own.

> “I wish notifications that were transient information by nature would automatically go away (which is one reason I turned a lot of them off; e.g. if “your battery is full” would show up and then go away on its own, I’d probably leave that kind of message on).” (INT#1)

There are also some applications that perhaps should keep notifications longer than they do, because participants noticed when they were gone.

> “I’d like a better history of notifications, even after I’ve viewed them, sometimes it would be nice to go back and check stuff again.” (INT#8)

6.6.9 Situational and Context-aware Notifications

Many participants expressed a desire only for notifications that tell them information under certain conditions.

> "It depends on the information on the mail. I have an IMAP account (with gmail), and I don't want notifications for some mails that I mark as read on income, for example." (UXR#47)

> "If I want to know whether I have new unread tweets I look at the tray icon. But if someone mentions me, a notification would be great." (UXR#174)

> "[Notification of] security updates mostly make sense, notification about a new version [of software] not so much." (UXR#217)

> “Sometimes I enable email notifications if I expect something important to arrive.” (INT#2)

> “I dislike that a random person gets the same 'loudness' as someone I'm waiting [to chat with], a family member, etc.” (INT#1)

> "Sometimes I disable these messages, depending on what I'm doing. If doing random stuff I like to see them, but not if I want to [concentrate]." (UXR#76)

One condition was a subset of a specific application or service notifications, such as only email from specific people.

> “When I'm expecting an email, I wish I could be notified only for certain addresses” (INT#2)

Another condition would be to only send a notification when an application or service is not currently in focus.

> “When the music player window is open on the same screen, the notification [about the music player and the information in view] is not interesting.” (UXR#212)

Some standard notifications might be valuable under normal circumstances, but the customized environment that some participants worked in often reduced the value of those notifications greatly.

> “I don't feel upgrade messages are that valuable, given I'm using [a development version of the operating system] that has ~100 upgrades

> per day. But I think I would [find the messages valuable] if I were using a less moving target." (INT#3)

6.6.10 Application Support and Integration

Notifications supported participants' interactions with many types of applications (as previously described).

> "[Notifications] remind me how to mount USB drives." (INT#2)

> "[I like] popups for chats (and with Telepathy [KDE chat program] that includes GTalk and Facebook which are the main ways to chat with non-geeks)" (INT)

> "Touchpad enabled/disabled is nice too, saves me having to test it" (INT)

There were some application notifications participants wanted but were not yet supported or supported well.

> "I would like browser notifications pop up in KDE notifications… and I want [command line terminal] notifications for when it returns to prompt." (INT#12)

For the most part, KDE applications integrate into the same notification system seamlessly. However, any Linux-supported application can be used in KDE, not just KDE applications. Non-KDE applications did not always use the standard notification system, and notifications from these applications did not integrate into the system well.

> "KDE doesn't seem to play nice when you don't use the KDE applications." (INT#9)

> "I wish there was one single notification system. I really dislike having so many different looking notification types that float around in different system tray icons." (INT#1)

In some cases, the same application did not coordinate even with itself when it sends notifications.

> "[Notifications] tell you there are updates available – and then they tell you there are security updates available. [Security updates are included in general update notifications]" (INT#9)

> "Our implementations [of notifications] is not that smart, and sometimes I get like four notifications because my four mail addresses fail to download (because my network went down) so all of the four flash pretty fast and it's like 'OK, I know something went wrong'" (INT#11)

6.6.11 Notification Configuration

The default notification settings were also considered to be pretty good by many participants.

> "The current default settings for [notifications] seem quite nicely suited to the average user's needs, so I'd probably not change that (much) either." (INT#14)

Keep in mind that many of the participants were technically competent and were comfortable with configuring changes in the environment.

There was room certainly room for improving defaults, usually on a one-off or application-specific basis.

> "We have some defaults that can be improved. [If I recall correctly] Akregator [KDE RSS reader] by default pops up every time a [individual] feed is updated." (INT#3)

Notification bugs (unintended behavior) were sometimes a source for complaints.

> "When copying files to USB [notifications] can be a bit buggy. Often if you copy say 5GB or more, [the notification] will lag behind for a while. Also, since [a recent version] when I try to shut down the system I get a notification that asks me if I want to restart or suspend to RAM." (INT#9)

Configurability in KDE is an important value and part of the KDE brand. Nearly all of the participants mentioned that they liked the fact that notifications can be configured.

> "I love that notifications are configurable in every KDE app…" (INT#8)

Specifically, participants liked that the notification configuration for applications and services was through a common configuration interface

> "What I do like is that notifications exist at all and that they're fairly pervasive. You can configure notifications to occur for nearly anything

> in KDE apps and they are easy to switch on/off centrally via the system settings." (INT#6)

However, notification configuration was at a high level of rule and feature granularity than what suited most participants' needs. Many participants described the need for more context-sensitive notification settings.

> "I want an easy way to override one or two particular notifications (enabling the mail notification is [a lot of work] and I only do it sometimes [because of this])." (INT#2)

> "I wish [notifications would] let me simply mute an application's notification for X amount of time…" (INT#7)

> "I would like to be able to configure how long notifications are shown, possibly a different setting per application. It would be useful to classify notifications by importance, for example: any mail from foo@bar.com is very important. For any message from User24, do not show a notification but save it in the notification history." (INT#13)

The problem with context-sensitive settings is that the more options built into the notification configuration system, the more complexity is introduced. However, it is obvious that more intelligent notification behavior would greatly improve the notification user experience.

Chapter 7: Discussion

As you can see in Chapter 6: Results, there is a large and complex system of factors that appear to be significant in the interruptive notification user experience in a lot of different ways. In the Discussion section, I tease out how these factors are significant and how they influence the user experience.

First, I define what I mean by the notification user experience (UX) and reference the framework from my Statement of Research. I use this framework to describe the implications of my research. Next, I list significant contextual factors of the notification UX present in my research. Then, I describe how these contextual factors interact and influence the notification UX, first through a table of documented influences, then a series of influence maps by UX context dimension, then finally individually illustrated in a series of models. These models are tied back to the Results as a way to easily match my assertions with evidence. Finally, I describe how to take advantage of the models of influence in the notification UX by providing a number of design guidelines based on the Results and resulting Notification Models.

7.1 Notification User Experience (UX)

User experience is defined as a user's “perceptions and responses that result from the use of or anticipated use of a product, system, or service” (ISO 9241-210:2009). There are different dimensions of characteristics about a product, system, or service that are external to the user experience that may affect how the user perceives and

respond to a product, system, or service. In this work, I define a framework of dimensions for the interruptive notification user experience context as (Figure 16):

- **User:** are characteristics about the user that may affect how the user perceives and responds to an interruptive notification. An example user characteristic would be the role of the user when they use the computer, such as a student, a hobbyist, or a worker.
- **Environment:** are characteristics about the user's role in the environment that may affect how the user perceives and responds to an interruptive notification more broadly than just the task, similar to a work sphere. For example, if a user is in a “working” environment, they will execute tasks, consume information, and make decisions influenced by the fact they are “working”.
- **User Task:** are characteristics about the user's main (interrupted) task that may affect how the user perceives and responds to an interruptive notification. An example user task characteristic would be the type of task activities the user is engaged with.
- **Notification:** are characteristics about the notification that may affect how the user perceives and responds to an interruptive notification. An example of notification characteristics would be the source of the interruptive notification or the content of the notification message.

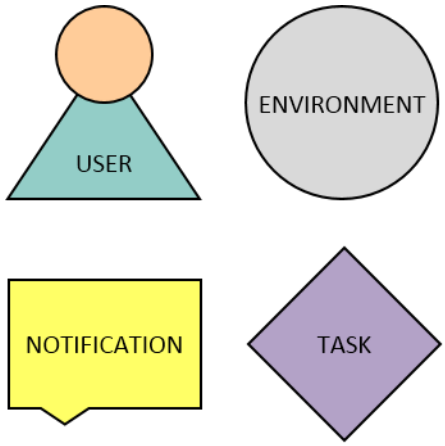


Figure 12: Dimensions of the Interruptive Notification User Experience Context

These dimensions provide a framework in which to understand and reference the influence that contextual factors may have on the interruptive notification user experience.

In the context of this work, UX was measured using the following two factors:

- **OWR Emotion:** UXR Q5 that asked participants to describe with one word their overall notification experience, then coded for positive or negative emotional tone. This factor provides a way to measure emotional impact and the lasting effects of use.
- **Future Notifications:** UXR Q4 that asked participants if they wanted similar notifications like the one received again in the future. This factor provides a way to measure user acceptance and the intent for future use.

7.2 Significant Contextual Factors

This section contains a list of significant (meaningful, not statistical) contextual factors identified in this research. In this research, a contextual factor is a variable that is external to the user experience that is dependent on the user, environment, task, or

notification. While there are many other factors discussed in the Results that may be interesting for future research, the factors listed in this section are factors with compelling evidence, relationships with other factors, and meaningful effects on the user experience. Figure 13 provides a summary map of significant contextual factors found in this research. The following sections describe the most influential categories of contextual factors.

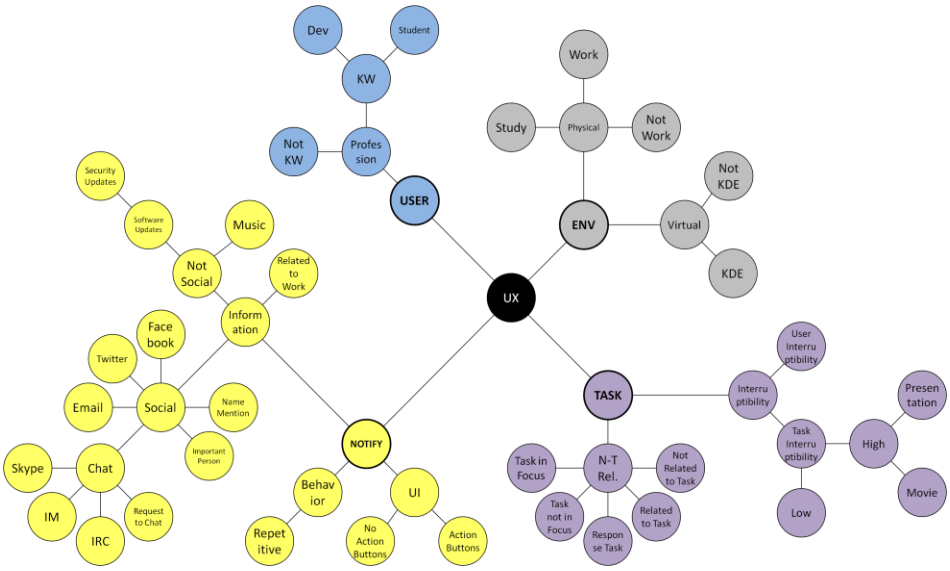


Figure 13: Map of significant contextual factors found in this research, organized by UX Context Dimension

7.2.1 User-related Contextual Factors

User-related contextual factors refer to characteristics about the user that may affect how the user perceives and responds to an interruptive notification.

7.2.1.1 Profession: Knowledge Worker

A *knowledge worker* is a person who completes tasks that require intensive levels of focus, analytic reasoning, and problem solving. Disruptions often result in a loss of

focus, requiring re-preparing to continue with the interrupted task. Two types of Knowledge workers were identified in this research:

- **Developer:** A person who performs tasks directly related to software development, including coding, compiling, and debugging, as well as related tasks such as responding to email, chatting with collaborators, reading documentation, etc.
- **Student:** A person who performs tasks related to learning, such as intensive reading and writing on familiar and unfamiliar topics, research, and collaboration with others.

7.2.1.2 Profession: Non-Knowledge Worker

A non-knowledge worker is a person who completes tasks that do not require intense levels of focus, analytic reasoning, and problem solving. Disruptions may result in a loss of focus, but with little or no consequence and regaining focus does not cost much. The most common non-knowledge workers in this researcher were casual users who were at home or in a café and were not currently in a work role.

7.2.2 Environment-related Contextual Factors

Environment-related contextual factors refer to details about the user's work environment that may affect how the user perceives and responds to an interruptive notification more broadly than just the task, similar to a work sphere. Two types of environments were identified in this research, a working environment and a studying environment.

7.2.2.1 Physical Environment: Work

In a work environment, a person is in a work sphere and responsible for interacting with colleagues, conducting certain types of tasks, and working with domain-specific information and knowledge.

In this research, while there is a logical implication that someone in a working environment is also a knowledge worker, the linking was not made and are treated as separate exclusive factors.

7.2.2.2 Physical Environment: Study

A studying environment was similar to a working environment in that the student had responsibilities, interactions, tasks, and knowledge. The difference is that the domain is specific to a learning environment.

In this research, while there is a logical implication that someone in a studying environment is also a student knowledge worker, the linking was not made and is treated as separate exclusive factors. However, the examples provided in the research happen to have data for both the student knowledge worker user and the studying environment.

7.2.2.3 Virtual Environment: KDE Applications

KDE is not only a desktop environment but a suite of applications and tools that follow a unified look and feel. In order to be branded as a “KDE application”, the software must meet certain standards for integration and usability. For example, all KDE applications must use the KDE notification system to send notification messages to the user, and not a home-grown service.

7.2.2.4 Virtual Environment: Not KDE Applications

At the same time, users are not limited to running only KDE applications. Any software that is supported on the Linux operating system can be run in KDE. However, these applications do not have to conform to KDE standards and use KDE-provided services when they interact with the user. For example, a non-KDE application does not have to use the KDE notification system to send a notification to the user; or, it might use the KDE notification system but does not conform to KDE's usability guidelines on how to do so.

7.2.3 User Task-related Contextual Factors

User task-related contextual factors refer to details about the user's main (interrupted) task that may affect how the user perceives and responds to an interruptive notification. There were several significant user task factors:

- **Notification-Task Relationship: Notification Task in Focus:** whether or not the notification is generated from the application in the user's current focus.
- **Notification-Task Relationship: Notification Response Task:** whether or not a notification supports reaction and the task elicited is in response to the notification.
- **Notification-Task Relationship: Notification Relatedness to Task:** whether or not the notification information or notification response is related to the user's current task.
- **Task Interruptibility:** is a characteristic of a task and refers to the degree to which a task can be interrupted (temporarily or permanently) and the effect on

usability. For example, a full-screen movie has low interruptibility and a notification would greatly disrupt it.

7.2.4 Notification-related Contextual Factors

Notification-related contextual factors refer to details about the notification that may affect how the user perceives and responds to an interruptive notification

7.2.4.1 Notification Information

Notification information is the data that will be presented to the user by the notification system. There were several significant notification information factors:

- **Social Notifications:** Notifications that support communication or collaboration with people. There are many types of social notifications (e.g., email, chat, Facebook), and purposes of social notifications (status update, request to chat).
- **Software Updates:** A type of system notification that provides awareness of the availability of new versions of installed software
- **Music:** Notifications that provide information about the currently playing music, such as album, artist, and song title.

7.2.4.2 Notification Behavior

Notification behavior is the logic and decision making executed by the system in order to determine how and in what way the user will be notified of the information. There was one significant notification behavior factors:

- **Notification Repetitiveness:** Notification system behavior in which the same or similar notifications are delivered to the user within a short period of time.

7.2.4.3 Notification User Interface

Notification user interface is the physical representation of the information according to the rules dictated by behavior. There was one significant notification user interface factor:

- **Support for Notification Reaction (Action Buttons):** Buttons on a pop-up notification that allow the user to perform an action related to or in response to the notification information.

7.3 Influential Contextual Factors on Notification User Experience

The presence of many of these contextual factors, alone or combined, affected the notification UX in a positive (want again in future and/or positive emotional words) or negative (do not want again in future and/or negative emotional words) way. Very few of these interactions were simple and the interaction of multiple contextual factors across different UX dimensions can become very complex (Figure 14).

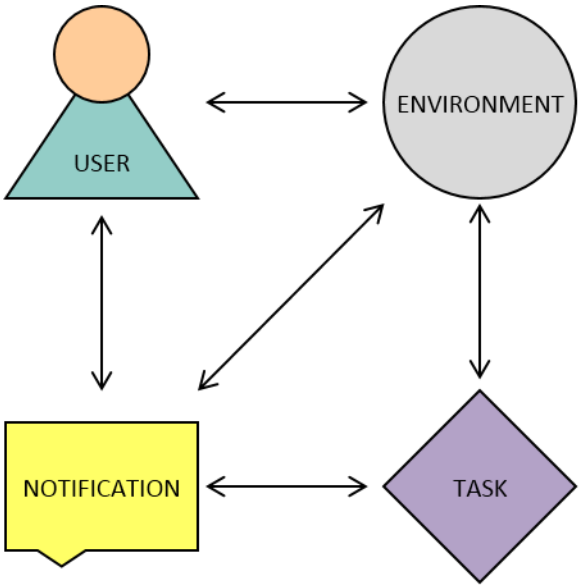


Figure 14: Interactions between contextual factors within notification UX dimensions

The following sections describe how the contextual factors found in this research interact with each other (described within the context of the notification UX dimensions) and influence the notification user experience in a positive, negative, or mixed way.

7.3.1 Positive UX Influences

There were a number of examples of interaction among contextual factors lead to a positive notification user experience (Table 51). Evidence that supports these influences are described in the Models of the Interruptive Notification User Experience section.

#	User	+	Environment	+	Task	+	Notification	= UX
I-1	Any	+	Any	+	Any	+	Any	= Positive
I-2	Knowledge Worker (Developer)	+	Any	+	Any	+	Information (Software Updates: Security)	= Positive
I-3	Not Knowledge Worker	+	Any	+	Any	+	Information (Software Updates: All)	= Positive
I-4	Knowledge Worker (Developer)	+	Any	+	Any	+	Information (Social: IRC, Chat, Email)	= Positive
I-5	Any	+	At Work (Office, Work from Home)	+	Any	+	Information (Any: Work Related)	= Positive
I-6	Any	+	Not at Work	+	Not Related to Task	+	Any	= Positive
I-7	Any	+	Not at Work	+	User Not Interrupted	+	Any	= Positive
I-8	Any	+	KDE Applications	+	Any	+	Any	= Positive
I-9	Any	+	Any	+	Task Not in Focus	+	Any	= Positive
I-10	Any	+	Any	+	Notification Response	+	User Interface (Yes Action Buttons)	= Positive

I-11	Any	+	Any	+	Any	+	Information (Social: All)	= Positive
I-12	Any	+	Any	+	Any	+	Information (Social: Request/update to chat)	= Positive
I-13	Any	+	Any	+	Any	+	Information (Social: Name mention)	= Positive
I-14	Any	+	Any	+	Any	+	Information (Social: Important Person)	= Positive

Table 51: Contextual Factors of Notification UX with Positive UX Influence

7.3.2 Negative UX Influences

There were a few examples of interaction among contextual factors lead to a negative notification user experience (Table 52). Evidence that supports these influences are described in the Models of the Interruptive Notification User Experience section.

#	User	+	Environment	+	Task	+	Notification	=	UX
I-15	Knowledge Worker (Student)	+	Studying	+	Any	+	Any	=	Negative
I-16	Knowledge Worker (Developer)	+	Any	+	Any	+	Information (Social: Twitter, Facebook)	=	Negative
I-17	Any	+	Not KDE Applications	+	Any	+	Any	=	Negative
I-18	Any	+	Any	+	Task Not Interruptible (PowerPoint, Movie)	+	Any	=	Negative
I-19	Any	+	Any	+	Task in Focus	+	Any	=	Negative
I-20	Any	+	Any	+	Not Related	+	Information (Not Social)	=	Negative
I-21	Any	+	Any	+	Notification Response	+	User Interface (No Action Buttons)	=	Negative
I-22	Any	+	Any	+	Any	+	Behavior (Repetitive)	=	Negative

Table 52: Contextual Factors of Notification UX with Negative UX Influence

7.3.3 Mixed UX Influences

There were some cases in which there was strong but conflicting evidence as to how several contextual factors affected the user experience (Table 53). Participants expressed either a strong like or dislike for certain factor influences. Additionally, some statistics showed both positive and negative influences for some factors that could not be resolved. Here, other factors are at play and I will explain them later in the Models of the Interruptive Notification Experience section. Evidence that supports these influences are described in the Models of the Interruptive Notification User Experience section.

#	User	+	Environment	+	Task	+	Notification	=	UX
I-23	Knowledge Worker	+	Any	+	Any	+	Any	=	< Positive
I-24	Any	+	At Work (Office, Work from Home)	+	Any	+	Any	=	< Positive
I-25	Any	+	Any	+	Any	+	Information (Social: Email)	=	Positive Negative
I-26	Any	+	Any	+	Any	+	Information (Music: All)	=	Positive Negative

Table 53: Contextual Factors of Notification UX with Mixed UX Influence

7.4 Models of the Interruptive Notification User Experience

Another way of understanding contextual factor influences in the notification user experience is to map the influences to the UX Dimensions framework. Figure 15 shows where within the framework of the four notification user experience dimensions that contextual factors interact and influence the notification user experience. No influences between the User and Task contextual dimensions were found.

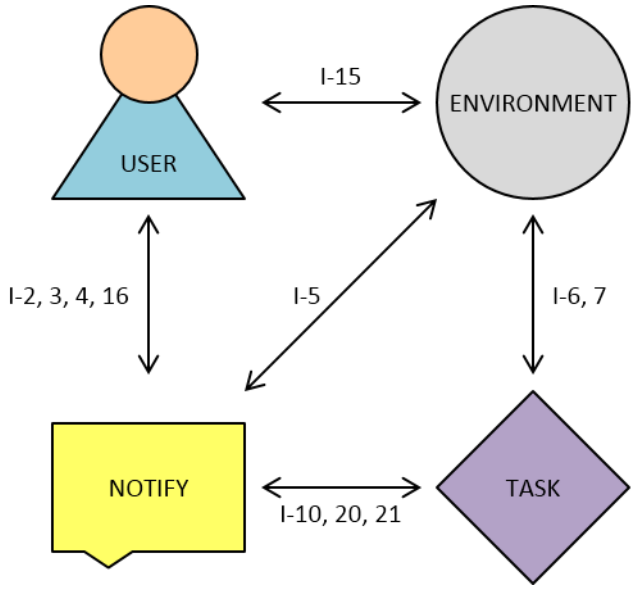


Figure 15: Specific influences of interactions between contextual factors within notification UX dimensions

As you can see, the notification user experience is fairly complex. To better explain how these contextual factors influence the notification user experience, a series of sub-models are presented that together represent the influential contextual factors notification user experience explored in this research.

Figure 16 presents the objects in the notification user experience model. These objects represent the previously defined UX dimensions for the interruptive notification user experience.

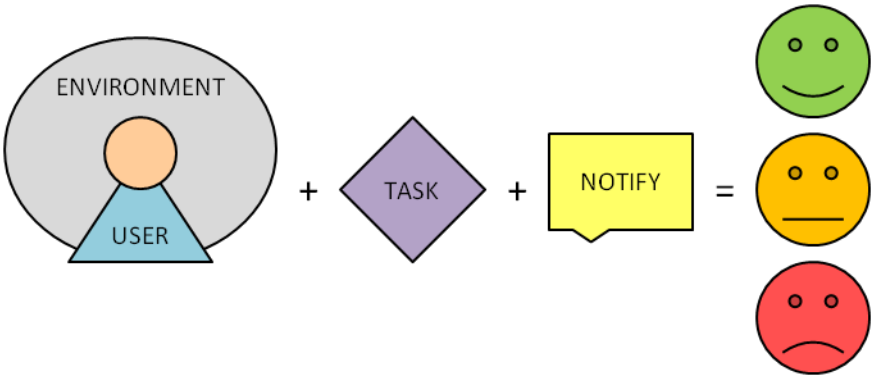


Figure 16: UX Dimension Objects in the Notification User Experience Model

The object shapes represent different dimensions of the notification UX:

- **User (circle + triangle):** Represents the types of users within the user UX dimension.
- **Environment (circle):** Represents the types of environments within the environment UX dimension.
- **Task (diamond):** Represents the types of user tasks within the task UX dimension.
- **Notify (square bubble):** Represents the types of notifications within the notification UX dimension.
- **Face (smile, frown, sad):** Represents a positive to negative heuristic scale for the overall notification UX (combined contribution of OWR Emotion and Future Notifications).

In KDE, notifications tend to be a positive experience by default (Figure 17). However, there are also a number of contextual factors that will influence the notification user experience toward the positive or negative.

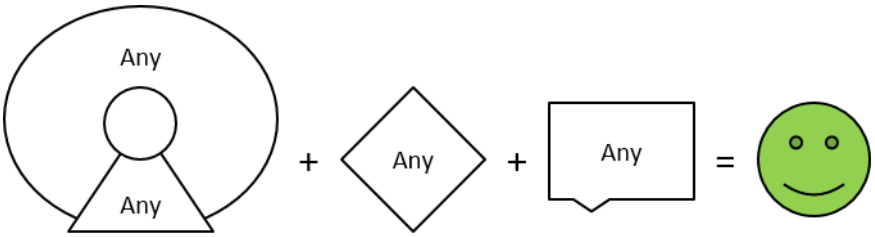


Figure 17: Notification UX tends toward the positive by default (I-1)

Evidence to support Contextual Factor Influence I-1:

- Table 5: Frequency of positive and negative One Word Responses
- Table 32: Future Notifications X OWR Emotion (Non-Social Notification Messages)
- Table 33: Future Notifications X OWR Emotion (Social Notification messages)
- Table 34: Future Notifications X OWR Emotion (Did Not Stop Current Task)
- Table 35: Future Notifications X OWR Emotion (Stopped Current Task)
- Table 36: Future Notifications X OWR Emotion (Not Working)
- Table 37: Future Notifications X OWR Emotion (Working)
- Table 38: Future Notifications X OWR Emotion (Desktop Computer)
- Table 39: Future Notifications X OWR Emotion (Laptop Computer)
- 6.4 Notifications in Support of Task Management

7.4.1 User Models

The user UX context dimension had a number of influences on the notification user experience. Figure 18 is a map of influences in the user UX context dimension. This map shows how other parts of the notification UX influence contextual factors within the user UX context dimension. Red arrows indicate negative influences, green

arrows indicate positive influences, and, orange arrows indicate mixed influences. For example, Facebook and Twitter notifications were negative influences on Developer's overall UX while Chat and Email notifications were positive influences on Developer's overall UX.

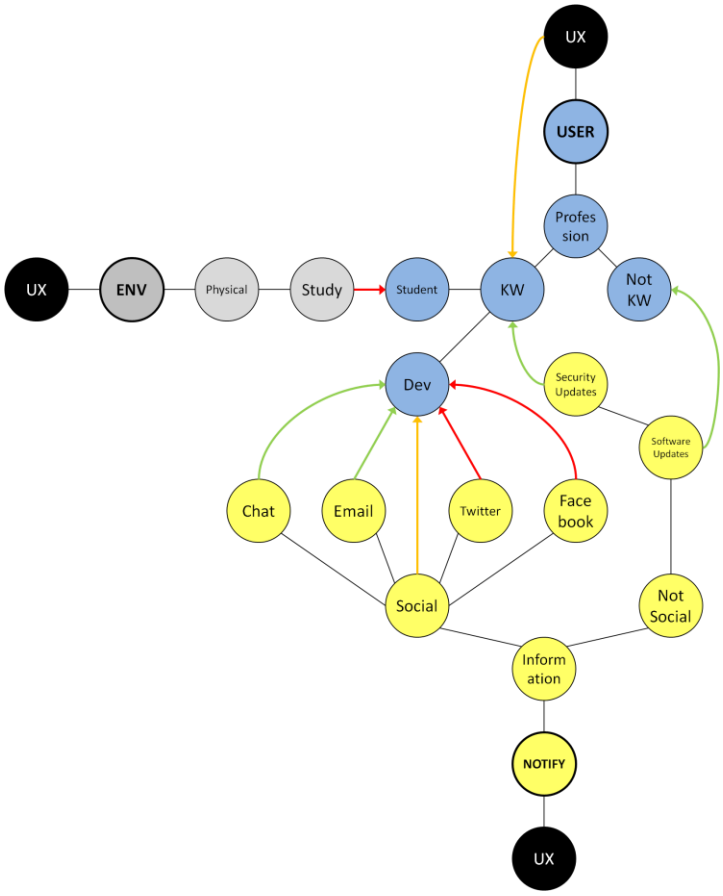


Figure 18: Influence Map of the User UX Context Dimension

7.4.1.1 Knowledge Workers and Notifications in General

In general, knowledge workers do not like interruptions and notifications will result in a less than positive notification user experience (Figure 19). There are exceptions to this general rule that are explained in later models.

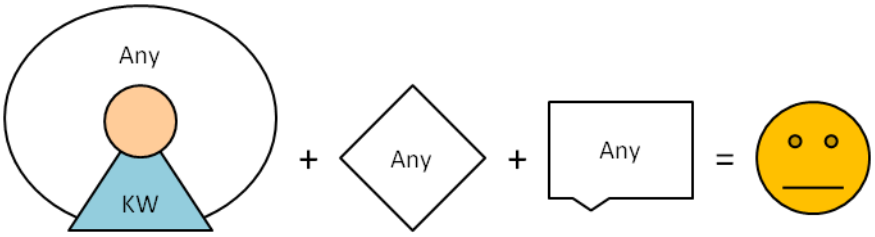


Figure 19: Knowledge Worker influence on general notification UX (I-23)

Evidence to support Contextual Factor Influence I-23:

- 6.3.3 Prioritization of Social Notifications
- 6.5 User Role and Environment

7.4.1.2 Knowledge Workers and Software Updates

There are notable differences between knowledge workers and non-knowledge workers and the effect of software update-related notifications (Figure 20). Non-knowledge workers have positive experiences with notifications related to software updates. Knowledge workers only have positive experiences with notifications related to security-related software updates. Perhaps this is because many of the knowledge workers in the UXR and Interviews were developers who manually controlled the exact version of software installed on their system out of necessity of their jobs.

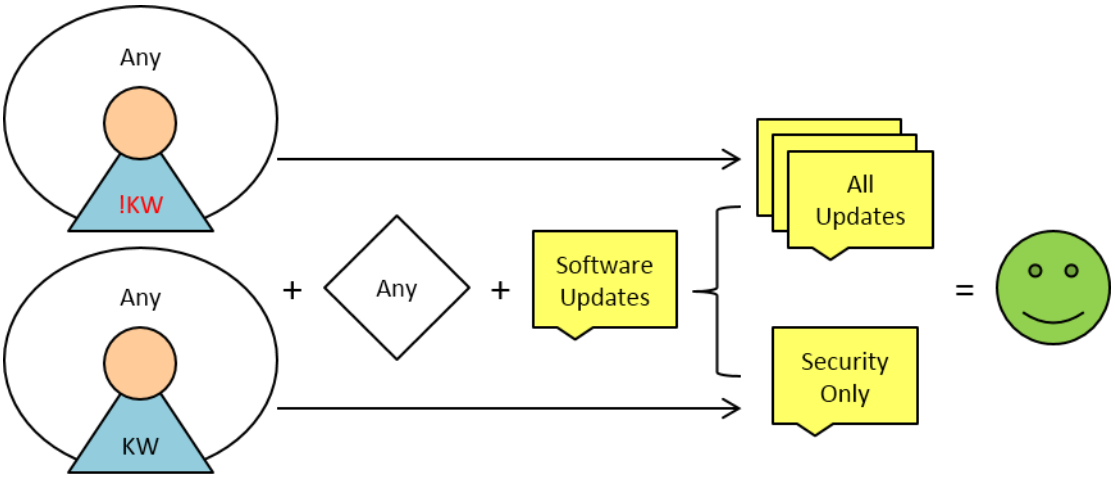


Figure 20: Knowledge Worker influence on notification UX for Software Updates (I-2, I-3)

Evidence to support Contextual Factor Influence I-2 and I-3:

- 6.5 User Role and Environment
- 6.6.9 Situational and Context-aware Notifications

7.4.1.3 Students while Studying

Knowledge workers who are students and in a studying environment experience a negative notification user experience (Figure 21).

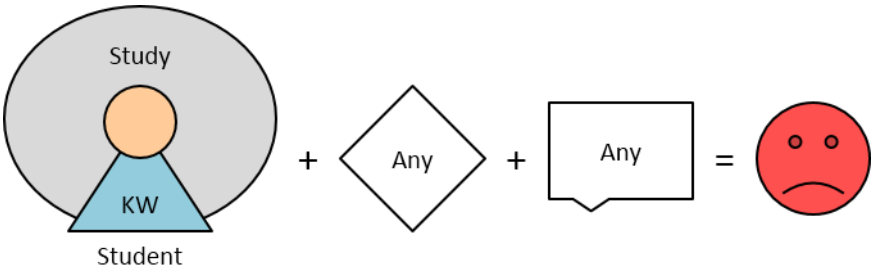


Figure 21: Knowledge Worker (Student) in a Study environment influence on notification UX (I-15)

Evidence to support Contextual Factor Influence I-15:

- 6.5 User Role and Environment

7.4.1.4 Developers and Social Notifications

Knowledge workers who are developers who receive social notifications experience both positive and negative notification user experiences (Figure 22). If a social notification is about a chat, IRC mention, or email, the experience is positive. These notifications support collaboration with others. If a social notification is about Twitter or Facebook updates, the experience is negative.

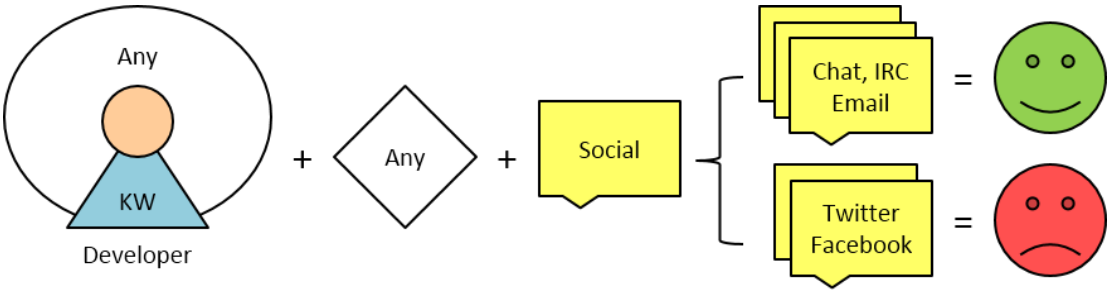


Figure 22: Knowledge Worker (Developer) influence on notification UX for different types of Social notifications (I-4, I-16)

Evidence to support Contextual Factor Influence I-4 and I-16:

- 6.3.1 Supporting Social Interactions
- 6.3.3 Prioritization of Social Notifications

7.4.2 Environment Models

The environment UX context dimension had a number of influences on the notification user experience. Figure 23 is a map of influences in the environment UX context dimension. This map shows how other parts of the notification UX influence contextual factors within the environment UX context dimension. Red arrows indicate negative influences, green arrows indicate positive influences, and, orange arrows indicate mixed influences. For example, notifications Related to Work were a positive UX influence in a Working environment.

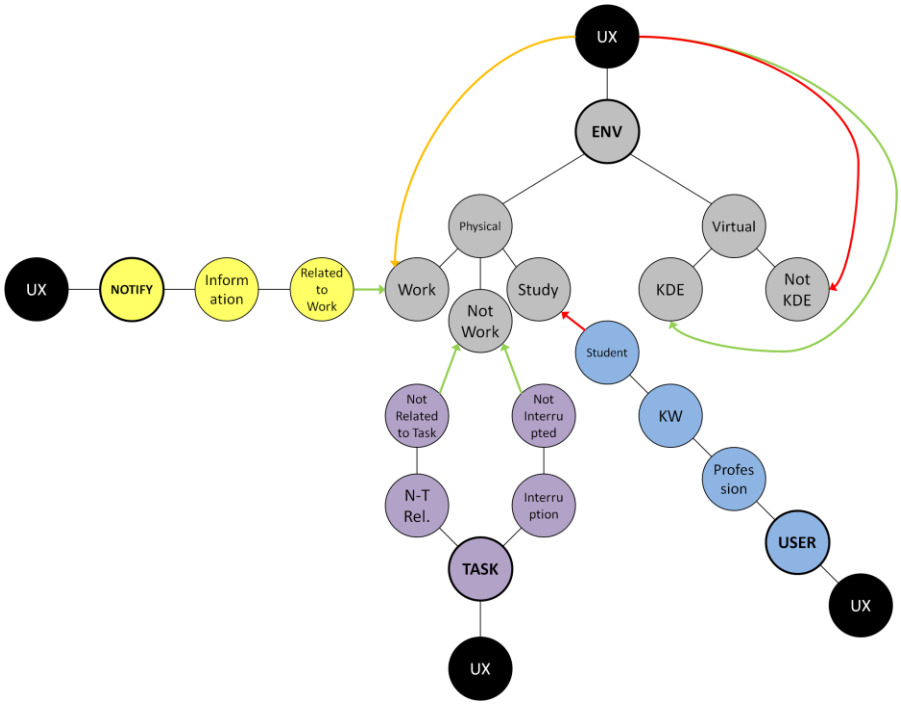


Figure 23: Influence Map of the Environment UX Context Dimension

7.4.2.1 Work Environment and Notifications in General

If a person is in a work environment they will generally not like interruptions and their notification experience will be less than positive (Figure 24). There are exceptions that are explained in later models.

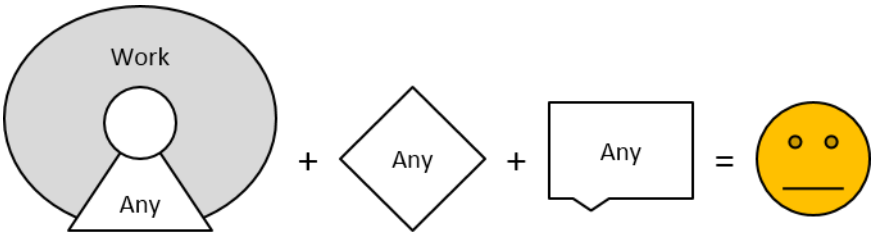


Figure 24: Work environment influence on notification UX in general (I-24)

Evidence to support Contextual Factor Influence I-24:

- 6.3.3 Prioritization of Social Notifications
- 6.5 User Role and Environment

If a notification is related to the work environment, the notification experience will be positive (Figure 25). Given this, I make the assumption that notifications would result in a negative experience.

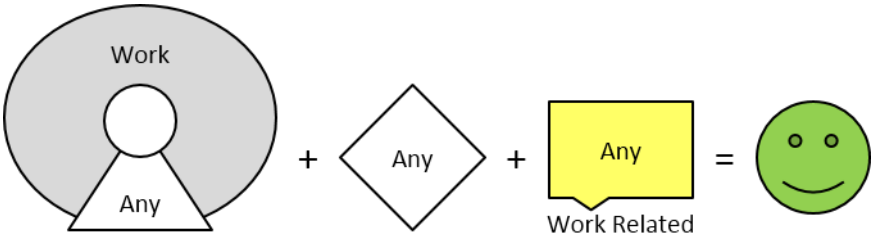


Figure 25: Work environment influence on Work Related notification UX (I-5)

Evidence to support Contextual Factor Influence I-5:

- 6.3.3 Prioritization of Social Notifications

7.4.2.2 Notifications Not Related to Task while Not in a Work Environment

If a person is not in a work environment and they receive a notification not related to their task, their notification user experience will be positive (Figure 26).

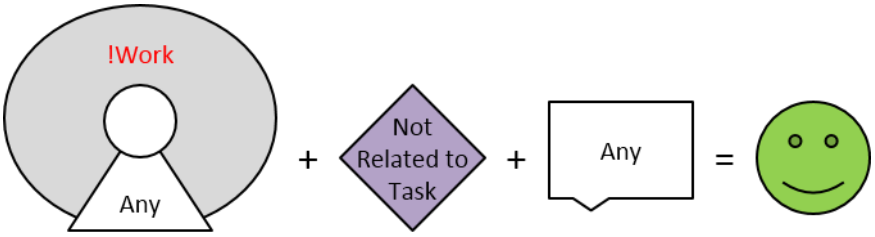


Figure 26: Not Work environment and notification Not Related to Task influence on notification UX (I-6)

Evidence to support Contextual Factor Influence I-6:

- Table 47: Related to Task X Working (Do Want Future Notifications Y/N Only)

7.4.2.3 Task Not Interrupted while Not in a Work Environment

If the task of a person who is not in a work environment is not greatly interrupted and the task is not disrupted, then notification user experience will be positive (Figure 27). Many people in the UXR study described useful notifications that were informational only and did not require a response, and the information could be understood from the popup user interface.

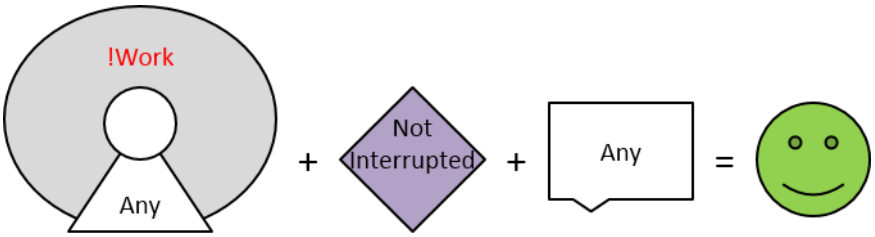


Figure 27: Not Work environment and Task Not Interrupted influence on notification UX (I-7)

Evidence to support Contextual Factor Influence I-7:

- Table 46: OWR Emotion X Stop Current Task (Not Working)

7.4.2.4 KDE Applications and Notifications

Notifications send by KDE applications will generally result in a positive user experience (Figure 28). Notifications sent by non-KDE applications will generally result in a negative user experience. KDE applications tend to have good defaults (there are exceptions) while non-KDE applications noticeably deviate from the general KDE user experience.

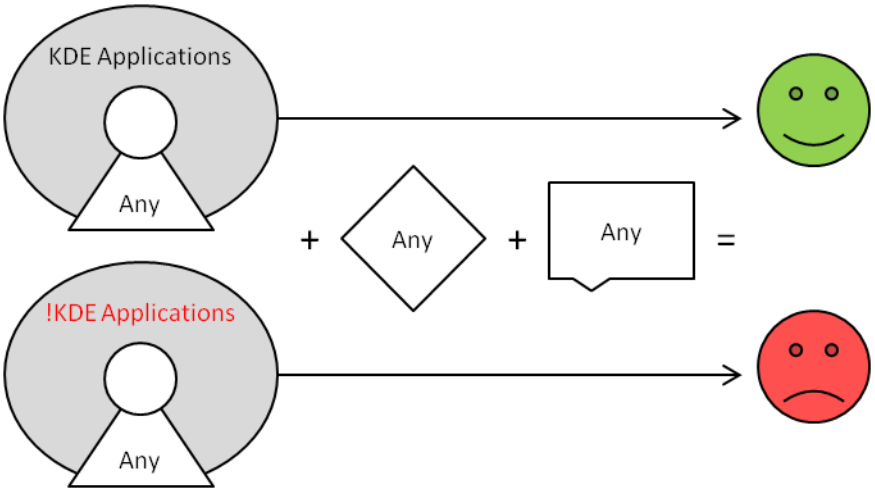


Figure 28: KDE Application environment influence on notification UX (I-8, I-17)

Evidence to support Contextual Factor Influence I-8 and I-17:

- 6.6.8 Notification Information Management
- 6.6.10 Application Support and Integration
- 6.6.11 Notification Configuration

7.4.3 Task Models

The task UX context dimension had a number of influences on the notification user experience. Figure 29 is a map of influences in the task UX context dimension. This map shows how other parts of the notification UX influence contextual factors within the task UX context dimension. Red arrows indicate negative influences, green arrows indicate positive influences, and, orange arrows indicate mixed influences. For example, For example, for notifications that have a potential response, the presence or absence of action buttons to support response had a positive or negative influence on the UX.

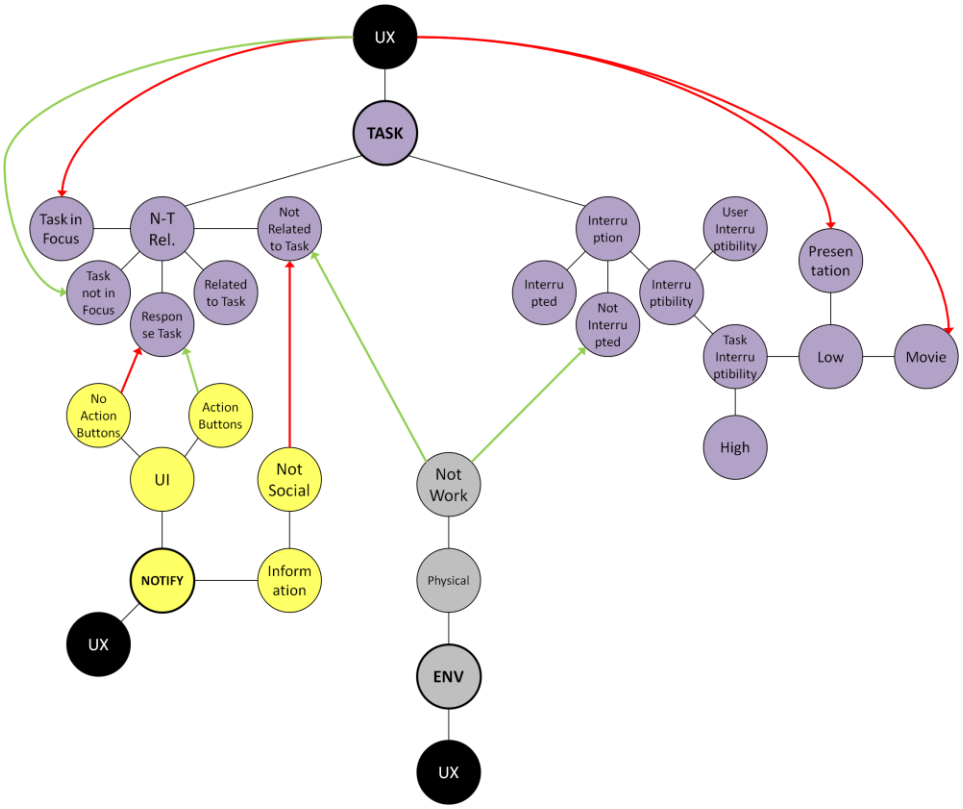


Figure 29: Influence Map of the Task UX Context Dimension

7.4.3.1 Task Interruptibility

Notifications received during a task with low interruptibility result in a negative user experience (Figure 30). Low interruptibility tasks include full-screen presentations and movies.

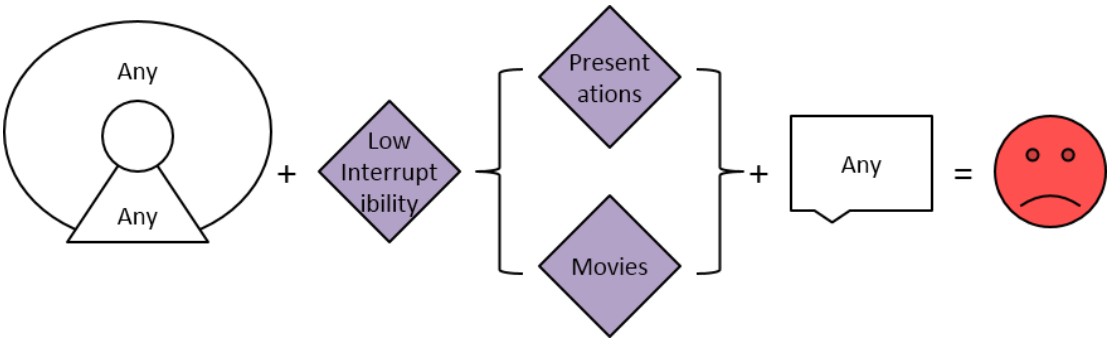


Figure 30: Low Task Interruptibility influence on notification UX (I-18)

Evidence to support Contextual Factor Influence I-18:

1. 6.4.4 Task Disruptions

7.4.3.2 Notification Not Related to Current Task and Not Social Notifications

Notifications received that are not social and not related to the current task will result in a negative user experience (Figure 31).

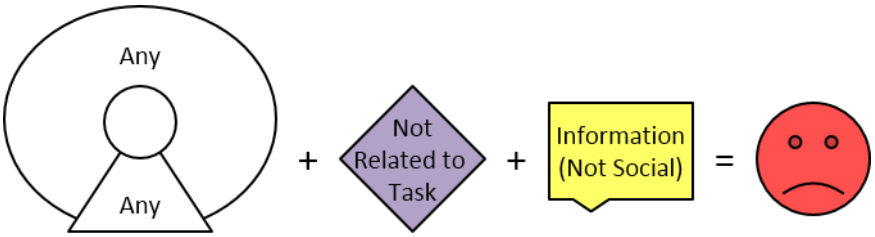


Figure 31: Not Social notifications received Not Related to Task influence on notification UX (I-20)

Evidence to support Contextual Factor Influence I-20:

- Table 41: Socialness X Related to Task (OWR Negative Emotion)

7.4.3.3 Notification Task Focus

Notifications related to a current task can have an effect on notification user experience (Figure 32). If a notification is related to the task currently in focus, the notification user experience will be negative. Usually it is likely that if the task is in focus, the person either caused the notification or can already see the information the notification is alerting on. If the notification is related to the task not currently in focus, the notification user experience will be positive. The notification is providing awareness of a task that a person may want awareness of.

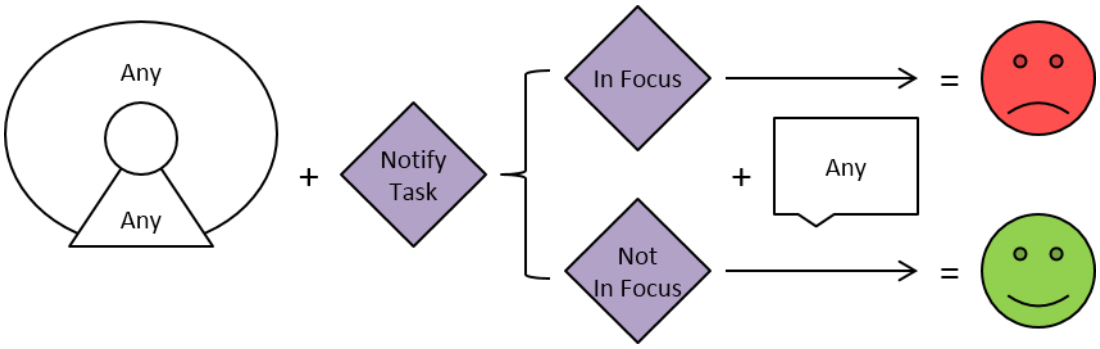


Figure 32: Notification Task Focus influence on notification UX (I-9, I-19)

Evidence to support Contextual Factor Influence I-9 and I-19:

- 6.6.4 Timeliness of Notifications
- 6.6.9 Situational and Context-aware Notifications

7.4.4 Notification Models

The task UX context dimension had a number of influences on the notification user experience. Figure 33 is a map of influences in the task UX context dimension. This map shows how other parts of the notification UX influence contextual factors within the task UX context dimension. Red arrows indicate negative influences, green arrows indicate positive influences, and, orange arrows indicate mixed influences. For example, For example, being a non-knowledge worker had a positive influence on notifications about software updates.

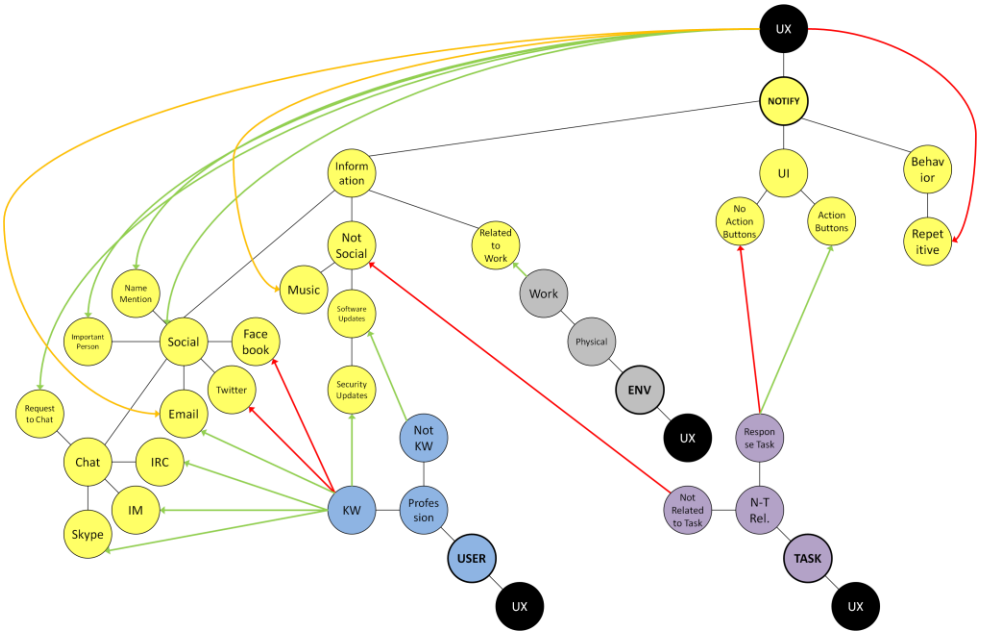


Figure 33: Influence Map of the Notification UX Context Dimension

7.4.4.1 Social Notifications

In general, social notifications will be a positive user experience (Figure 34).

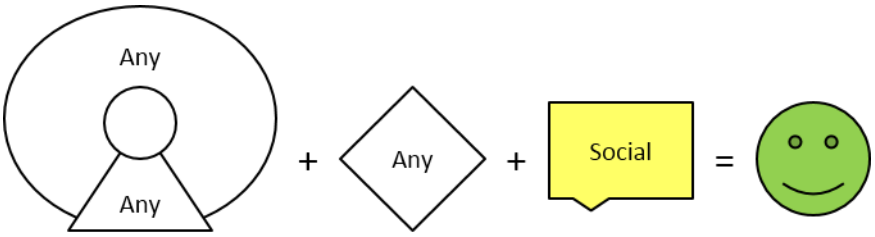


Figure 34: General Socialness influence on notification UX (I-11)

Evidence to support Contextual Factor Influence I-11:

- Table 33: Future Notifications X OWR Emotion (Social Notification messages)

Specific social notifications that elicit the most positive notification user experiences are those related to requests/continuations of chats, name mentions in chat/IRC or

Twitter/Facebook feeds, and social notifications from an important person (Figure 35).

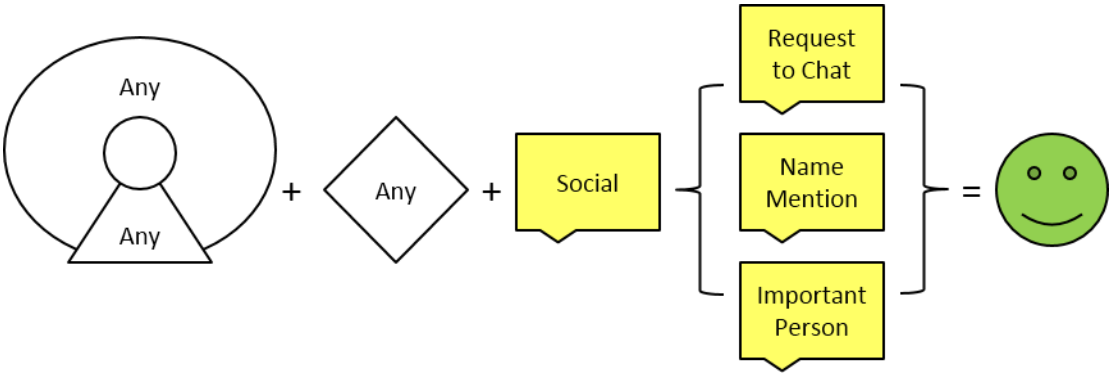


Figure 35: Specific Social influences on notification UX (I-12, I-13, I-14)

Evidence to support Contextual Factor Influence I-12, I-13, and I-14:

- 6.3.1 Supporting Social Interactions
- 6.3.2 Conversations with People
- 6.3.3 Prioritization of Social Notifications
- 6.6.11 Notification Configuration

7.4.4.2 Repetitive Notifications

Any notification that produces repetitive notifications over a short period of time, regardless of how valuable, important, or useful a single notification may be, will result in a negative notification user experience (Figure 36).

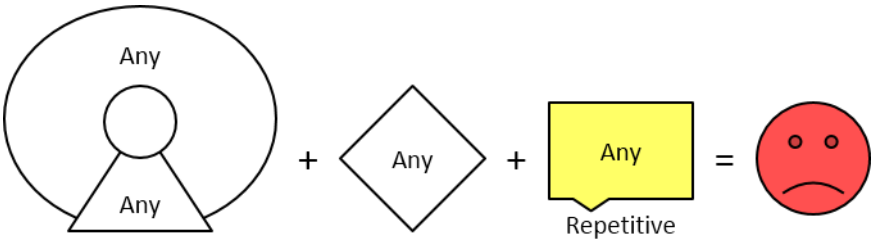


Figure 36: Repetitive notification influence on notification UX (I-22)

Evidence to support Contextual Factor Influence I-22:

- 6.6.3 Frequency of Notifications

7.4.4.3 Action Buttons for Notification Reaction

The presence or absence of action buttons on notifications that have a possible action or reaction affect the notification user experience (Figure 37). Notifications that have a possible action or reaction and provide action buttons will result in a positive user experience. Notifications that have a possible action or reaction and do not provide action buttons will result in a negative user experience.

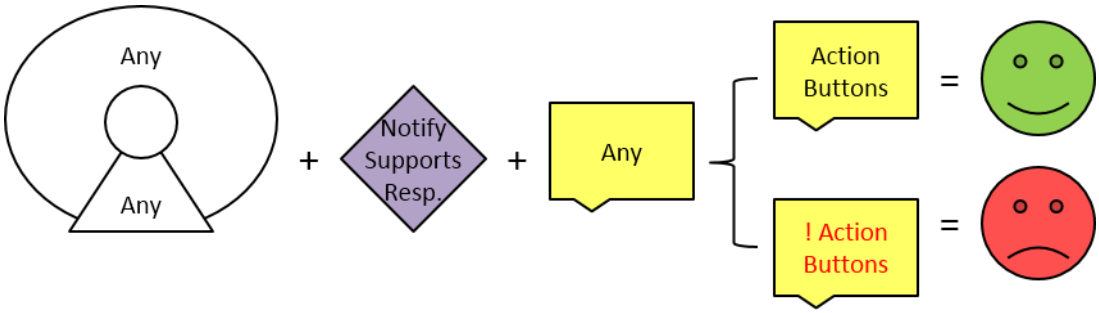


Figure 37: Action Buttons to support notification response influence on notification UX (I-10, I-21)

Evidence to support Contextual Factor Influence I-10 and I-21:

- 6.6.7 Interacting with and Responding to Notifications

7.4.4.4 Personal Preference

The user experience of some notifications comes down to personal preference (Figure 38). For example, people really like music notifications and some people find them very annoying. Likewise, some people really like new email notifications and some people do not want to be notified of new email at all.

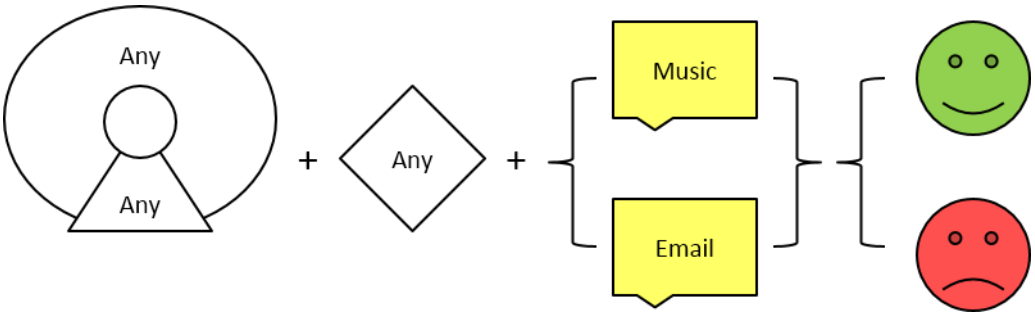


Figure 38: Music and Email influence on notification UX (I-25, I-26)

Evidence to support Contextual Factor Influence I-25 and I-26:

- 6.3.1 Supporting Social Interactions
- 6.6.2 Music Players
- 6.6.11 Notification Configuration

7.5 Interruptive Notification System Design Guidelines

A series of interruptive notification system design guidelines were derived from the results and analysis of this research. These guidelines are evidence-based design recommendations that are specific enough to have an immediate effect on the KDE environment but general enough to provide useful insights to other desktop notification systems. While these guidelines were influenced by KDE knowledge workers, the KDE environment, and the KDE notification system, the guidelines are written in a way that could generalize to any similar desktop-based interruptive notification system for knowledge workers.

Guidelines are structured as follows:

- The design rule to follow for positive notification user experience.
- Additional description if needed to explain or elaborate on the rule.
- Example that helps describe the proper or improper use of the rule.

- Evidence from research, including references to related influence models and additional supporting evidence that is not implied by the influence model.

The guidelines are ordered from general guidelines to more specific rules.

7.5.1 Be sensitive to the context of use

Context can sometimes be generalized and that should be used to the notification system's advantage. For example, if a user is currently working, allow them to switch to the "work" context and adjust notification behavior to optimize the user experience for a working environment. (I-2, I-3, I-4, I-5, I-6, I-7, I-16, I-23, I-24; 6.6.7 Interacting with and Responding to Notifications)

7.5.2 Make it easy to configure notifications

Some people like notifications for certain things and others do not. For applications with strong polarizing preferences (such as email, music), it is especially important to support users customizing the notification environment. The many contextual factors that influenced whether or not people wanted to receive a notification require a very flexible and highly customizable notification system. For example, email and music were two applications that users either strongly liked or disliked notifications. (I-25, I-26) (See Figure 39).

Figure 39: Example music notification that would benefit from each configuration to match personal preference

7.5.3 Provide a way to customize receipt of notifications based on contextual features

Context is sometimes defined as a number of exceptions and not as a rule. For example, allow a user to receive new email notifications only for certain senders, such as important social contacts. (I-13, I-14)

7.5.4 Only interrupt the user with a notification when something unexpected happens

Do not use notifications to confirm expected behavior, especially when the user generated the notification alert or the action is confirmed by the user interface in focus. For example, if a user just clicked the Send Email button do not display a notification confirming the email was sent since success is expected. (I-9, I-19) (See Figure 40).

Figure 40: Example notification that confirms expected behavior.

7.5.5 Only use a notification if it can provide useful information to the user

Do not use a notification to alert the user if it does not provide enough information for the user to learn something or make a decision. Information is critical to help the user determine the priority of the notification task. For example, a notification that informs the user that a service cannot connect should provide information to help diagnose the problem. (6.3.1 Supporting Social Interactions, 6.3.3 Prioritization of Social Notifications, 6.4.3 Task Prioritization, 6.6.10 Application Support and Integration) (See Figure 41).

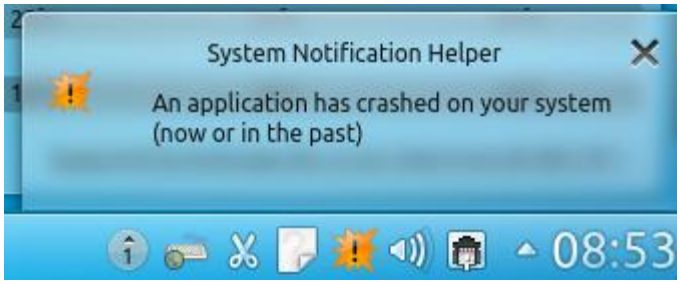


Figure 41: Example notification that does not provide useful information.

7.5.6 Do not interrupt a very important task or a task that has consequences if it is interrupted.

For example, this includes many tasks that are completed in full-screen windows (such as movies or presentations). (I-18) (See Figure 42).

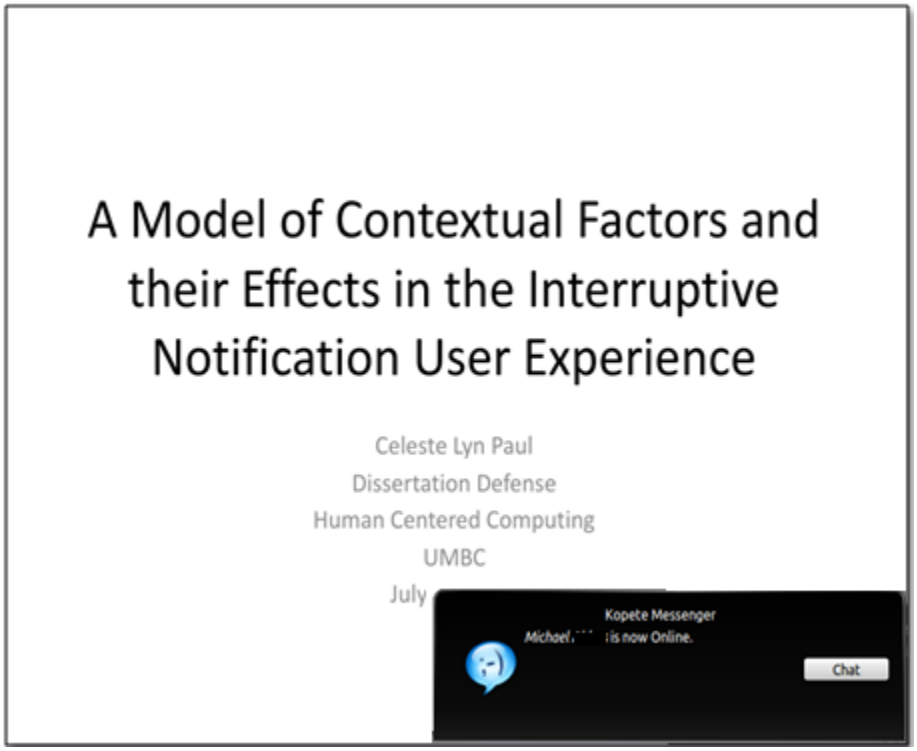


Figure 42: Example notification that was displayed during a task that had low interruptibility

7.5.7 Provide only one notification for the first of many related updates

Do not cascade repetitive or related notifications in a short period of time. For example, online/offline status of a contact produces many notifications that people don't care about. (I-22) (See Figure 43)

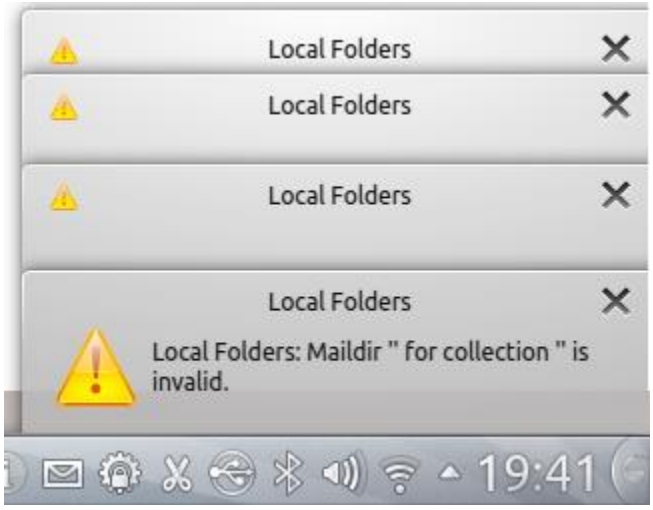


Figure 43: Example notification with repetitive display behavior

7.5.8 Provide a way for the user to react or respond to the notification within the notification user interface when possible

Fix the actions on pop-up notifications; they are broken for some applications. For example, allow users to respond to a chat notification with a respond/read button or inline text input box. (I-10, I-21) (See Figure 44).

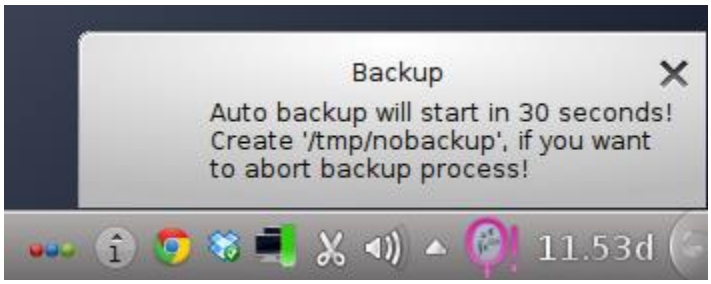


Figure 44: Example notification that would benefit from an action button in the notification popup

7.5.9 Use notifications to provide status of ongoing tasks that last for a long period of time.

Do not use notifications to provide status of very short activities especially if the start and end of the activity is less than the time it takes for a user to forget about the

activity (maybe around 10 seconds). For example, very short file downloads that only take a few seconds do not need notifications. (I-22)

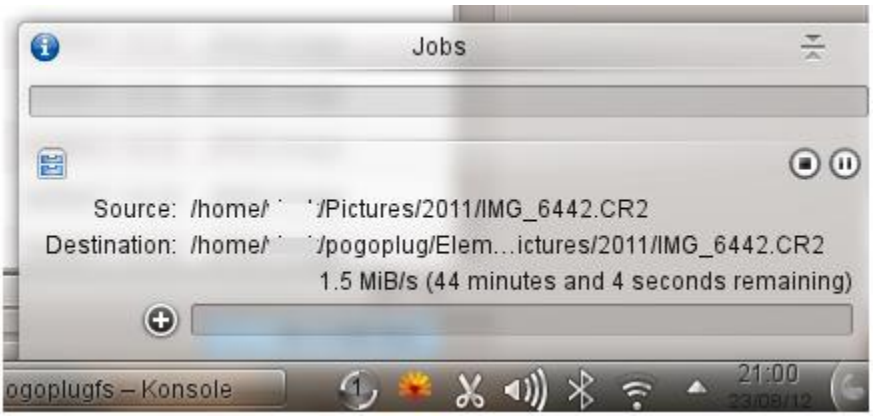


Figure 45: Example notification for a long-term task

7.5.10 A notification is more useful when an application is not currently in focus

Also, a notification is not always relevant from an application not currently in use. For example, if in the application updater a user clicks the 'update sources' file, do not display a notification that "new updates are available" if that information is also shown in the interface. (I-9, I-19) (See Figure 46).

Figure 46: Example notification that displays an error for the application in focus

7.5.11 Expire irrelevant notifications

Some notification information has a lifespan. Once the information is out of date or no longer relevant, remove the information. For example, a notification about a battery reaching full charge is only interesting a few moments after it happens and would not be relevant if the laptop remains plugged in, or if the battery begins discharging again. (6.6.8 Notification Information Management)

Figure 47: Example notifications that are ephemeral and would benefit from auto-expiration

7.5.12 Check related software bugs that might inadvertently affect user experience

Notification system bugs will affect the user experience of the application that sends the notification. Even if the software is well-designed, poor design in dependent services will still affect your perceived experience. (I-8, I-17)

Chapter 8: Conclusions

In this dissertation, I studied a variety of knowledge workers who were involved in the KDE open source software project. While modern computing for casual users is moving towards a more ubiquitous and mobile platform, knowledge workers rely on desktop computers in order to do their jobs. The daily work of knowledge workers involves critical thinking, communicating with people, and using productivity applications that are only available and best suited for a desktop environment. Notifications are an important service that helps knowledge workers successfully manage their tasks.

Figure 48 summarizes the application of this work.

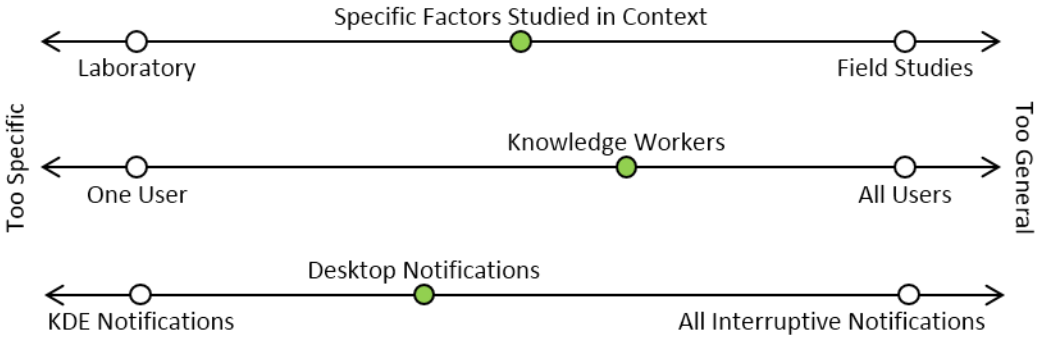


Figure 48: Summary of the application of this research

Previous research had examined selected contextual factors that affect the notification user experience, no comprehensive model tailored for knowledge working has been published in the literature (more detail in Chapter 2: Related Work). Quantitative studies focused on single variables or simple relationships and qualitative ethnographic studies were often focused on a narrow domain. I began to fill this gap between quantitative and qualitative research by using a mixed approach—creating an

in-depth comprehensive understanding of notifications through the study of related contextual factors and their influences on the user experience.

As described in the Results, there is a large and complex system of factors that appear to be significant in the interruptive notification user experience in a lot of different ways. In the Discussion section, I teased out how these factors are significant and how they influence the user experience.

In general, knowledge workers (developers) had positive notification user experiences and felt that notifications supported their work well. These knowledge workers, while in a working context, preferred work-related notifications. I found that knowledge workers worked in a variety of contexts and preferred notifications that supported their current context. Social notifications also supported a positive notification user experience. Again, knowledge workers preferred social notifications that supported their working context; although in general all users liked all types of social notifications. Poorly designed notifications that did not provide useful information, did not provide a way to easily react to the notification, or had generally poor timing, contributed to a negative user experience for knowledge workers and general users alike. The results of this research tells us that the design of an effective and satisfactory desktop notification system should keep flexibility and configurability in mind.

The dimensions of the notification user experience context – user, environment, task, and notification – provide a framework to understand contextual factors that affect notification user experience. This framework helps describe the implications of my

research by organizing the significant contextual factors I found in my research. The map (Figure 13) of these contextual factors shows the breadth of factors that have an influence on the notification user experience. The influences between these contextual factors demonstrate the complexity of this environment, as illustrated in a series of influence models (Figure 18, Figure 23, Figure 29, Figure 33). To make understanding the value of the influence models, I present a series of individual influence models that are tied back to relevant evidence in the Results.

Finally, I describe how to take advantage of the models of influence in the notification user experience by providing a number of design guidelines based on the contextual factor influence models as well as additional findings in the Results. These guidelines provide a range of recommendations that address general issues related to desktop notification user experience to specific issues to the KDE notification system.

While the focus of my research was on people from the KDE community, the results are transferable to many other domains and settings where knowledge workers accomplish their tasks using desktop systems. Notifications will continue to play an important role in assisting desktop users, including software developer-type knowledge workers, with managing their services. Continuing to investigate the interruptive notification user is essential for supporting a future knowledge worker-friendly desktop environment. The notification models and desktop guidelines developed as part of my work have the potential to impact the work environment, usability of notifications, and the general user experience of desktop system for a large number of users in the future.

8.1 Contributions

- List of contextual factors that affect the interruptive notification user experience. (7.2 Significant Contextual Factors)
- Models of identified contextual factors interacting with each other and influencing the user experience. (7.3 Influential Contextual Factors on Notification User Experience and 7.4 Models of the Interruptive Notification User Experience)
- Design guidelines to help improve the interruptive notification user experience. (7.5 Interruptive Notification System Design Guidelines)

Figure 49 summarizes the contributions of this research.

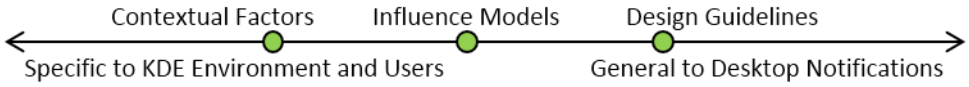


Figure 49: Summary of the research contributions

8.2 Limitations and Challenges

Participating in the study was a type of interruption and disruption to participant's tasks. However, the quality of responses by participants and the large number of experiences collected in the UXR provided greater benefits than the drawback to potentially missing certain types of experiences.

The participants in this research were advanced computer users and may have had strategies on how to respond and adapt to a hostile user environment. However, many users become "kings of their castles" and excel in certain skills through practice and experience. Learning from these users may provide insights to what problems exist in

the environment, especially since these users may have the technical vocabulary to describe the problems and solutions they experience.

This research also focused on knowledge workers that are primarily software developers and is limited in the assumptions it can make about all knowledge workers and casual users. While software developers have characteristics specific to their work, they share common traits with other knowledge workers such as a need for concentration, deep thinking, and a sensitivity to interruptions.

Additionally, the focus on desktop computers (specifically, KDE) limits the assumptions that can be made about all notifications, such as those on mobile platforms (tablets and mobile phones). This research also focused on the KDE notification environment. Although KDE is very similar to other popular desktop environments (such as, Gnome, Ubuntu Unity, Mac OSX Series, Windows XP, Windows Vista, Windows 7) it also comes with its own customizations.

Finally, this research only begins to look at contextual factors of the notification user experience. For example, there is a lot more to be learned about other aspects of interruptive notifications, such as the role of interruptive notifications in task management. While it was able to bridge the gap between the specific laboratory environment and general field study, additional work in this area is needed.

8.3 Future Work

The scope of this dissertation was to explore and present contextual factors of the interruptive notification user experience. There is much more future work possible to extend this dissertation. First, I plan to continue working with the KDE community

and transfer my notification guidelines to their KDE-specific Human Interface Guidelines in preparation for KDE 5 development (KDE 2013). I also plan to conduct a review of the current KDE notification system and submit bug reports and recommendations on how to improve application- and service-specific notification information, behavior, and user interface. Finally, the results of this work extend beyond the user experience context. I plan to continue analyzing the data from the UXR and Interviews, specifically to explore the role of notifications in task management.

8.4 Related Publications

Paul, C.L. and Komlodi, A. (2012). Emotion as an Indicator for Future Interruptive Notification Experiences. In proceedings of ACM CHI 2012, Extended Abstracts, 2003-2008.

Paul, C.L., Komlodi, A., and Lutters, W. (2011). The Emotional Experience of Social Notification Interruptions. In proceedings of IFIP INTERACT 2011, 471-478.

Paul, C.L. and Komlodi, A. (2010). Celeste Lyn Paul: Dissertation Proposal Literature Review. UMBC IS 801 Independent Project (Spring 2010), Final Paper.

Paul, C.L. (2009). Identifying Important User Interface Features in Notification Systems. UMBC IS 760 Human-Computer Interaction (Fall 2009), Final Paper.

Paul, C.L. and Komlodi, A. (2009). A Review of Interruptions in Desktop Notification Systems. UMBC IS 801 Independent Project (Spring 2009), Final Paper.

Appendices

Appendix 1: UMBC IRB Approval for Exploratory Notification User Experience Study

UMBC

AN HONORS UNIVERSITY IN MARYLAND

Human and Animal Research
Protections Office
University of Maryland, Baltimore County
1000 Hilltop Circle
Baltimore, MD 21250

PHONE: 410-455-2737
FAX: 410-455-3868
EMAIL: HARPO@umbc.edu

Date: November 29, 2010

To: Celeste Lyn Paul
Anita Komlodi

From: The Human and Animal Research Protections Office

Re: Exemption Certificate
Protocol # : **Y11AK12073**

The Institutional Review Board has reviewed your protocol entitled **Study of notification user experience** and has approved the application for certification as it met the criteria under **[category [(§46.101(b)(2)]** for exemption from further IRB review. The date of approval is 11/24/2010.

Annual review is not required for this protocol since it was determined to be exempt. However, any changes to the research design or procedures that could introduce new or increased risks to human subjects must be submitted ***in writing*** for review by the IRB before the changes are incorporated to insure they do not change the exempt status of the protocol. All correspondence and materials used in this protocol must reference the above IRB number.

Please refer to the IRB *Researcher's Guide*, found via the Human and Animal Research Protections Office web site (http://www.umbc.edu/research/HARPO/), for additional information about the administration of your protocol.

If you have any questions, please contact HARPO via the above phone number or e-mail.

Cc: Timothy Sparklin

Exempt review approved by:

Susan Sonnenschein, Ph.D.
IRB Chair

Appendix 2: Exploratory Notification User Experience Study

A survey about pop-up notifications

By clicking Accept, you acknowledge that you are willing to participate in academic research and the information collected in this survey may be used and reported to the public. No personal information will be requested. This study has been reviewed and approved by the UMBC Institutional Review Board (IRB). A representative of that Board, from the Human and Animal Research Protections Office, is available to discuss the review process or my rights as a research participant. Contact information of the Office is (410) 455-2737 or HARPO@umbc.edu

Pop-up notifications are the little message boxes or bubbles that appear in the bottom-right corner of your screen that alert you of new information or events. This survey would like to know more about your pop-up notifications from social communication applications (e.g. Facebook, LinkedIn, MySpace, Twitter, Flickr, Netflix, blogs, forums, email, text or voice chat)

Only respond if you have received a social communication application pop-up notification in the past 60 minutes. (HINT: keep this HIT open until you receive a notification)

Example social communication:

- New or incoming messages from friends, groups, or email
- Changes or updates in online status
- Changes or updates in status messages
- Content updates such as new or updated blog entry, page, picture, profile
- Administrative alerts from social communication applications
- Other notifications from social communication applications or services

Notification Survey

1. Describe the most recent pop-up notification you received

2. Describe what were you doing at the time of the notification

3. How long ago did you receive the notification
    - Less than 5 minutes ago
    - 6 to 10 minutes ago
    - 10 to 30 minutes ago
    - 31 to 60 minutes ago
    - Over 60 minutes ago

4. Select which type of notification you received
    - Notification Bubble (Image)
    - Notification Dialog (Image)
    - Unknown (Image)

5. Describe the type of notification message (e.g. New email message, Software updates available)

6. What application or service of the notification came from (e.g. AOL Instant Messenger, Facebook, Windows Updates)

7. Did you feel that you needed to take action or respond to the notification?
    - Yes
    - No
    - Not Sure
    - Why or why not?

8. Did you take action or respond to the notification?
    - Yes, immediately (less than 2 minutes)
    - Yes, but not right away (more than 2 minutes)
    - No
    - Why or why not?

9. Rate the notification based on the following qualities: (5-Point Scale)
    - Not very valuable/Very valuable
    - Not very interesting/Very interesting
    - Not very useful/Very useful
    - Not very important/Very important
    - Not very urgent/Very urgent

10. Which of these qualities is the most important to you when receiving any notification:
    - Value
    - Interest
    - Useful
    - Important
    - Urgent

11. How often would you want notifications like the one you received in the future?
    - Always
    - Sometimes
    - Never
    - Why or why not?

12. Using one word, how would you describe the notification you received?

13. (Optional) Gender:
    - Male
    - Female

14. (Optional) Age range:
    - < 18
    - 18-24
    - 25-34
    - 35-54
    - 55+

15. (Optional) Operating system:

Appendix 3: UMBC IRB Approval for KDE Notification User Experience Report and User Interview Studies

UMBC

AN HONORS UNIVERSITY IN MARYLAND

Office for Research Protections and Compliance
University of Maryland, Baltimore County
1000 Hilltop Circle
Baltimore, MD 21250

PHONE: 410-455-2737
FAX: 410-455-3868
EMAIL: compliance@umbc.edu

Date: July 26, 2012

To: Celeste Lyn Paul
Anita Komlodi

Re: Expedited Review Approval
Protocol # : **Y13AK12001**

Your protocol entitled **Defining the Contextual Factors and Understanding their Effects on the User Experience of Interruption and Notification** has been **approved by expedited review** by the Institutional Review Board. This study fulfills the criteria for expedited review under 45 CFR 46.110, category # **6&7** as ☒ *less than minimal risk* or ☐ *minimal risk* and applies, if applicable, to the following sponsored project titles and numbers:

-
-
-

Approval of this protocol will terminate on the below end date unless an Annual Continuation Report is submitted, in writing, to the IRB. The Office for Research Protections and Compliance will send you an email reminder prior to the end of the protocol; it is your responsibility, however, to assure that project activities are not conducted past the expiration date.

Reporting Calendar

Original approval date	Current end date	The next Annual Continuation Report is due by	Expect a reminder to renew by
07/24/2012	***07/23/2013***	**06/25/2013**	**06/11/2013**

Investigators are responsible for reporting ***in writing*** to the IRB any changes to the human subject research protocol, measures or in the informed consent documents. This includes changes to the research design or procedures that could introduce new or increased risks to human subjects and thereby change the nature of the research. In addition, you must report any adverse events or unanticipated problems to the IRB for review and approval. All correspondence and materials used in this protocol must reference the above IRB number.

Investigators are also reminded that all UMBC IRB approved consent forms will display an expiration date at the bottom of each page. Please check this date carefully each time an approved consent form is used, as using an expired form to consent participants is considered a substantial deviation from the Federal regulations governing research involving human subjects.

The investigator(s) identified above are required to retain an IRB protocol file, including a record of IRB-related activity, data summaries and consent forms. This file is to be made available for review for internal procedural (audit) monitoring.

Expedited review approved by:

Susan Sonnenschein, Ph.D.
IRB Chair

Appendix 4: KDE Notification User Experience Report Study

Instructions

This study asks you to describe a recent KDE notification experience. Notifications are the information boxes that appear in the corner of your screen to give you information. We are interested in learning more about how you react to these notifications.

The next time you receive a notification and have 5-10 minutes to respond:

- Take a screenshot of your desktop. You do not need to capture the notification in your screenshot
- Visit this survey start page and click Next
- Upload your screenshot and complete the questionnaire

If you have sensitive information viewable, such as a webpage open with bank information, please hide it before you take the screenshot (For example, you could open a new browser tab or switch windows).

Try to submit your screenshot and experience report within 5 minutes of the notification. That's OK if you don't have the opportunity to do it in that time, just wait until the next notification.

Don't worry if the notification was interesting or not, we are interested in all types of notifications. The most important part is that you accurately complete the experience report to the best of your ability.

We suggest you bookmark the study page so you can easily access it after the notification.

When you are ready to submit your experience report click Next

By clicking Next, you acknowledge that you are willing to participate in academic research and that the information reported in this survey may be used and reported to the public in an aggregated and anonymized format. You will be asked to report on a recent notification experience. Any personal information requested is optional. You will be compensated for your participation by a $1 donation to the KDE e.V. on your behalf. Approved for use (Y13AK12001) UMBC Institutional Review Board 07/24/2012 through 07/23/2013.

About the Notification

1. Upload a screenshot of your KDE desktop as it was when you received the notification.

- You must click the Upload button to submit your file. Your file will be listed on the page if Upload is successful.
- Alternatively you can copy the URL of an image upload website.

2. What was the notification about?

3. What service or application sent the notification?

4. Would you want a notification like this again in the future?
    - Yes
    - No
    - It depends
    - Why or why not?

5. Using one word, how would you describe your overall notification experience?

About Your Task

6. What were you doing at the time of the notification?

7. Did you stop what you were doing when you received the notification?
    - Yes
    - No
    - Why or why not?

8. Was the notification related to the task it interrupted?
    - Yes
    - No
    - Please explain.

9. What best describes your use of the computer at the time of the notification:
    - I was at work
    - I was working from home
    - I was at school
    - I was working on school work
    - I was at home
    - Other
    - Please explain Other:

About Yourself

10. Job Role/Title

11. Age

12. Gender
    - Male

- Female

13. Country

14. Computer
    - Laptop
    - Desktop
    - Tablet
    - Phone

15. English Language Proficiency
    - Native Speaker
    - Fluent (Business-level)
    - Conversational (Tourist-level)
    - Little/None

16. Education Level
    - High school
    - Some college
    - College degree (AA, BA, BS)
    - Graduate or Professional degree (MFA, MS, PhD, MD, JD)

17. Role in KDE
    - Developer
    - Contributor
    - Supporter
    - User

Follow-up Information

We are conducting follow-up interviews with a subset of participants.

- Please contact me for a follow-up interview

- Email

Feel free to provide feedback or comments about the survey

Thank You!

Thank you for your participation.

Updates on the progress of the study and KDE e.V. donation status will be posted @celestelynpaul.

If you indicated you are willing to participate in a follow-up interview, you will be contacted within the next 4 weeks.

Appendix 5: KDE Notification User Experience Study Axial Codes

- **Notification Information Message (Q2)**
  - Confirmation or completion of an action
  - Awareness of activity/information updates
  - Critical updates or errors
  - Current or timely information (the "now")
  - A directive to take action
  - Status of an ongoing action or service
  - Incorrect/Irrelevant/Untimely Information ("too little too late")

- **Social Notifications (all questions)**
  - Awareness of social interaction
  - Prioritization of social interaction with other tasks

- **Task Management (Q7 and Q8)**
  - Task overlapping – notifications allow users to manage multiple tasks or activities at the same time.
  - Task switching cues – notifications provide cues to users when they can switch to a new task
  - Temporary task switch – the primary task activity did not change but was briefly interrupted
  - Task prioritization – which task to attend to first/next

- **User Interface Comments (all questions)**
  - Notification behavior
  - Notification display
  - Notification message

- **Task Interruption due to Notifications (Q7)**
  - Informational notifications
  - Interruption priority
  - Notification scheduling
  - Notification value
  - Relationship to current task
  - Focus stealing
  - Notification management
  - Cannot respond to notification

- **Conditions to Receive a Notification (Q4)**
  - Only need one message for first of many related updates
  - Only interrupt when something unexpected happens
  - Do not interrupt very important tasks that have consequences if interrupted
  - Status notifications are more useful for longer activities

- Notification relevancy to current task in focus
- Only for (or not for) special types of information
- Option to react to a message or event
- Notifications for awareness in an IT/collaborative environment

- **Awareness (all questions)**
  - Awareness of activity/information updates
  - Awareness of social interactions
  - General, provides awareness of changes in information and activity
  - Notifications for awareness in an IT/collaborative environment

- **Multi-Tasking (Q7 and Q8)**
  - Task overlapping – notifications allow users to manage multiple tasks or activities at the same time.
  - Notifications can be attended to at a later time or be part of task-switching/multi-tasking

Appendix 6: KDE Notification Interviews Consent and Demographics Survey

Instructions

This interview asks you to discuss your KDE notification experiences. Notifications are the information boxes that appear in the corner of your screen to give you information. We are interested in learning more about how you react to these notifications.

Before the interview, we would like to collect some background information about yourself. Then, we will talk more (outside this survey) about your KDE notification experiences.

When you are ready to submit your background information, click Next

By clicking Next, you acknowledge that you are willing to participate in academic research and that the information reported in this survey may be used and reported to the public in an aggregated and anonymized format. You will be asked to report on a recent notification experience. Any personal information requested is optional. You will be compensated for your participation by a $5 donation to the KDE e.V. on your behalf. Approved for use (Y13AK12001) UMBC Institutional Review Board 07/24/2012 through 07/23/2013.

About Yourself

- Name (First only or nickname is OK)

- Job Role/Title

- Role in KDE
    - Developer
    - Contributor
    - Supporter
    - User

- Education Level
    - High school
    - Some college
    - College degree (AA, BA, BS)
    - Graduate or Professional degree (MFA, MS, PhD, MD, JD)

- English Language Proficiency
    - Native Speaker
    - Fluent (Business-level)
    - Conversational (Tourist-level)

    - Little/None

- Computer
    - Laptop
    - Desktop
    - Tablet
    - Phone

- Country

- Gender
    - Male
    - Female

- Age
    - 18-24
    - 25-34
    - 35-44
    - 45-54
    - 55-64
    - 65+

Thank You

Thank you for your information. Updates on the progress of the study and KDE e.V. donation status will be posted @celestelynpaul.

Appendix 7: KDE Notification Interview Guide

Social Context of Notifications

- Is it important that a notification tell you about messages or activity from other people?
- What about compared to other types of notification messages?
- Do you prefer social notifications over non-social notifications?
- What notification messages might be more important than notifications about other people?
- Under what circumstances do you respond to a message about or from a person right away and when do you postpone response? (Socialness X Stop Task)
- What features or behavior about social notifications do you like or dislike? (Socialness X UX)
- Do you use social media to interact with other KDE developers and users?
- How much do you rely on notifications from these social messages to participate in the community?
- How would your participation in the community be impacted if you did not have notifications about new updates to KDE-related social media?
- How important is timeliness to responding to these types of activities?
- What types of social notification messages would you always want? Not ever want? (Socialness X UX)

Task Management

- Are you a multi-tasker? Explain...
- Many activities but all related to the same goal
- Many activities that have different goals
- One thing at a time
- Other? Multiple?
- Do notifications help or hinder your multi-tasking? How? (Stop Current Task, Related to Current Task X UX)
- Does where you are or what you are supposed to be doing (such as working) affect how you use or view notifications? (User Role X UX)
- What types of notifications help you the most with managing tasks? The least? (Task Management X UX)

Action Buttons on Notifications

- Do you ever receive notifications that have buttons you can click on?
- Do you use the action buttons on the notification?

- Do you rely on the buttons on the notification to complete your task or provide shortcuts?

Notification UX

- Recalling some recent notification experiences, what were some of the most annoying and most useful features? (Notification UI* X UX)
- Notification timing (e.g., repetitiveness) (*Notification Behavior)
- Notification information (e.g., useful, not useful) (*Notification Information)
- Notification display (e.g., ugly, in the way of other parts of the screen) (*Notification UI)
- What are 5 ways you would improve the current notification system?
- What are 5 things you would not change about the current notification system?

Music Players

- Do you use Amarok or another music player that produces notification?
- How do you use the notifications from the music player?
- What features or behavior about music notifications do you like or dislike?

Environment

- Do you customize your KDE desktop or do you use the default theme? Do you think your choice affects the behavior of notifications?
- Have you ever customized the behavior or look/feel of the notifications? If so which ones? If not, why?
- Do you use a laptop or desktop? Do you think this form factor affects how you experience notifications?
- Do you use multiple screens? Do you think this form factor affects how you experience notifications?

Closing

- Is there anything else you'd like to discuss about the notification system before we end the interview?

Glossary

Term	Definition
Attention	The capacity of a user's concentration for an activity and awareness of external events.
Attentional Draw	The amount of attention attracted by an interruption's notification method (Gluck et al. 2007)
Context	The relationship of the interruption to the user's current tasks and goals.
Cost of interruption	Negative effects as a result of an interruption (Miyata and Norman 1986)
Disruption	A delay in the continuity of a task.
Interrupted task (Main task)	The task of the user's focus at the time of an interruption
Interruptibility	The degree to which a user or task can be interrupted (temporarily or permanently) and the effect on usability
Interruption	Forcefully switching attention from one piece of information to another
Interruption compensation	Change in user behavior due to expected task interruption
Interruptive task	The resulting task for attending to an interruption
Knowledge worker	A person who completes tasks that require intensive levels of focus, analytic reasoning, and problem solving
Memory load, or working memory	The amount of information that can be stored in short-term memory at any time (Miyata and Norman 1986)
Mental effort, or cognitive effort	The amount of mental load required to complete a task
Mental load, or cognitive load	The load on working memory during a task (Miyata and Norman 1986)
Notification	A service provided by the desktop system to help users maintain awareness of events and information while they work
Main task (Interrupted task)	The task of the user's focus at the time of an interruption
Task stabilization	An activity in which the user prepares to leave a primary task before switching to an interruptive task (Iqbal and Horvitz 2007)
Urgency	The perceived importance to quickly respond to an interruption
Usability	The efficiency, effectiveness, and satisfaction of a product, system, or service (ISO 9241-11:1998)
User experience	A person's perceptions and responses that result from the use of or anticipated use of a product, system, or service (ISO 9241-210:2009)
Work fragmentation	Breaks in continuous work activity (Avrahami et al. 2008)
Work sphere	A collection of tasks related to a single goal (Gonzalez and Mark 2004)

Table 54: Terms and Definitions used within this work.

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