TOWARDS HANDLING WORKER EMOTIONS FOR IMPROVED PRODUCT DEVELOPMENT

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ABSTRACT

Product development is a process in which important decisions pertaining to the artefact and its interaction with other life-phase systems are made. The consequences of these interactions influence in a direct manner the degree of success of product development in terms of cost, time and quality. One type of consequence which emanates from the interaction involving the human worker and other life-phase systems is the elicitation of human emotions. The investigation presented in this paper indicates that the elicitation of negative emotions from human workers can have significant ramifications on the product development process. The main contribution of this paper is the development of a support means which enables product development stakeholders to foresee the type of emotions elicited from human workers as a consequence of decisions made.

1 INTRODUCTION

Product development comprises a set of activities in which a perceived market opportunity is transformed into an artefact which is designed, fabricated and sold profitably to the customer [Krishnan & Ulrich, 2014]. These activities involve a multidisciplinary team of stakeholders, who are constantly making decisions with regards to the artefact and the systems required to support its realisation. Research into product development typically employs three dimensions, all of which related to profit, in order to gauge the success of the development process. These dimensions are: (i) the product development time, (ii) the cost of the artefact and the development project and (iii) product quality which reflects the extent to which the developed artefact is able to fulfil the customers' needs [Ulrich & Eppinger, 2003].

Throughout its diverse life phases, the artefact meets or interacts with a variety of systems [Borg, 1999] such as: fabrication machinery, assembly tools, the user and disposal systems. For many years, research into product development contributed to the creation of guidelines and other tools in order to support stakeholders in foreseeing the consequences of the meetings involving the artefact with other life-phase systems. A case in point are the design for X (DfX) guidelines such as design for manufacturing and assembly [Boothroyd, Dewhurst, & Knight, 2010] and design for recycling [Hundal, 2000]. These guidelines support product development stakeholders in managing the meeting with the artefact and other life-phase systems, with the intent to eliminate unforeseen and unintended consequences [Borg, 1999] which may threaten the success of product development.

Unlike traditional research into product development, this paper focuses on the emotions elicited from human workers. The elicitation of worker emotions is considered to be a consequence of the meeting between human workers and other systems such as fabrication equipment. The elicitation of undesirable emotions from human workers such as anger, dissatisfaction and fear may be of relevance to product development. The elicited negative emotions have an adverse effect on the execution of tasks such as fabrication and assembly. In turn, this may contribute to increased product cost, development time and deter the quality of manufactured artefacts.

The objective of this paper is to contribute towards providing a support means to designers in order to help them anticipate the emotions elicited from human workers as a consequence of product development decisions. The research work will therefore put stakeholders in a better position to

improve product development, by handling the emotions elicited from human workers who interact with various life-phase systems.

The next section of this paper will present a review of literature pertaining to the emerging field of research on product design and human emotions. The scope of section 3 is to accentuate to the reader the relevance of research into human worker emotions within the context of product development. For this purpose, section 3 presents the results of an empirical study that was carried out by the authors of this paper. The objective of this study was to understand the extent to which the elicitation of undesirable worker emotions can influence product development. Section 4 presents the second part of the empirical study which was carried out in order to understand the concerns of human workers. The emerging results contribute towards providing an insight as to how product development decisions have a capacity in influencing the concerns of human workers and elicit negative emotions. The conclusions pertaining to the research work presented are disclosed in section 5.

2   A REVIEW OF RESEARCH IN PRODUCT DESIGN AND HUMAN EMOTIONS

In recent years, research into product design has expressed a keen interest in the emotions elicited from humans as a consequence of their interaction with the artefact. This interaction occurs via the human senses and is commonly termed as human-product interaction. The research work by Ludden and Schifferstein [Ludden & Schifferstein, 2009] investigated the influence of product odours on the customers' evaluation. Fenko *et al.* [Fenko, Schifferstein, & Hekkert, 2011] investigated the impact of product 'noise' on the customers' experience of a product. The term 'noise' was used to refer to both the auditory property and cluttered visual patterns of the product. In their study Fenko *et al.* [Fenko et al., 2011] concluded that the noise emanating from the auditory property of the product had significantly more influence on the users' experience when compared to cluttered visual patterns. The research presented by Rahman [Rahman, 2012] investigated the influence of both visual and tactile stimuli on the evaluation of a clothing article by the end customers. The study concludes that both visual and tactile stimuli when combined together contribute significantly to influence the customers' evaluation.

A notable research contribution in the context of product design and customer emotions was the development of a comprehensive yet practical taxonomy of emotion prototypes intended to be employed by product design teams [Desmet, 2012]. The contribution of the work by Desmet was that existing typologies were either incomplete or else too impractical to be used by product designers in a realistic setting. While many products are designed with the intent to enrich the experience of the customer by eliciting positively toned emotions, Desmet and Fokkinga [S. F. Fokkinga & Desmet, 2013; S. Fokkinga & Desmet, 2012] show how the elicitation of negative emotions can also contribute to enrich the customers' experience of a product.

In their research work, Fenech an Borg [Fenech & Borg, 2006a] proposed a phenomena model of emotion elicitation through product design. This phenomena model was later adopted in the development of an approach [Fenech & Borg, 2006b] which is intended at providing design for emotions support. This particular approach was later implemented into a prototype design tool [Farrugia, Borg, Grima, & Fenech, 2008] which makes use of computer aided sketching in order to proactively support the synthesis of products which have a form that elicits positive emotions from the customers.

A significant limitation of the reviewed research work is that it exclusively focuses on the emotions elicited from the human customers while interacting with the finished product during the use phase. The emotions elicited are a consequence of the meeting between the human customer and the developed product. Yet such meetings involving humans and the artefact are not limited to the use phase. The research in this paper broadens the meaning of the term 'human-product interactions' as to include human workers who interact/meet with the evolving artefact during other life-phases such as fabrication and assembly. This paper will outline the relevance of the emotions elicited particularly from human workers in the context of product development.

2.1   The Underlying Process of Human Emotion Elicitation

Before proceeding any further, it is worth explaining to the reader the process through which human emotions are elicited. The process of human emotion elicitation is called the appraisal process [R. S. Lazarus & Folkman, 1984; R. Lazarus, 2006] and is illustrated in Figure 6.
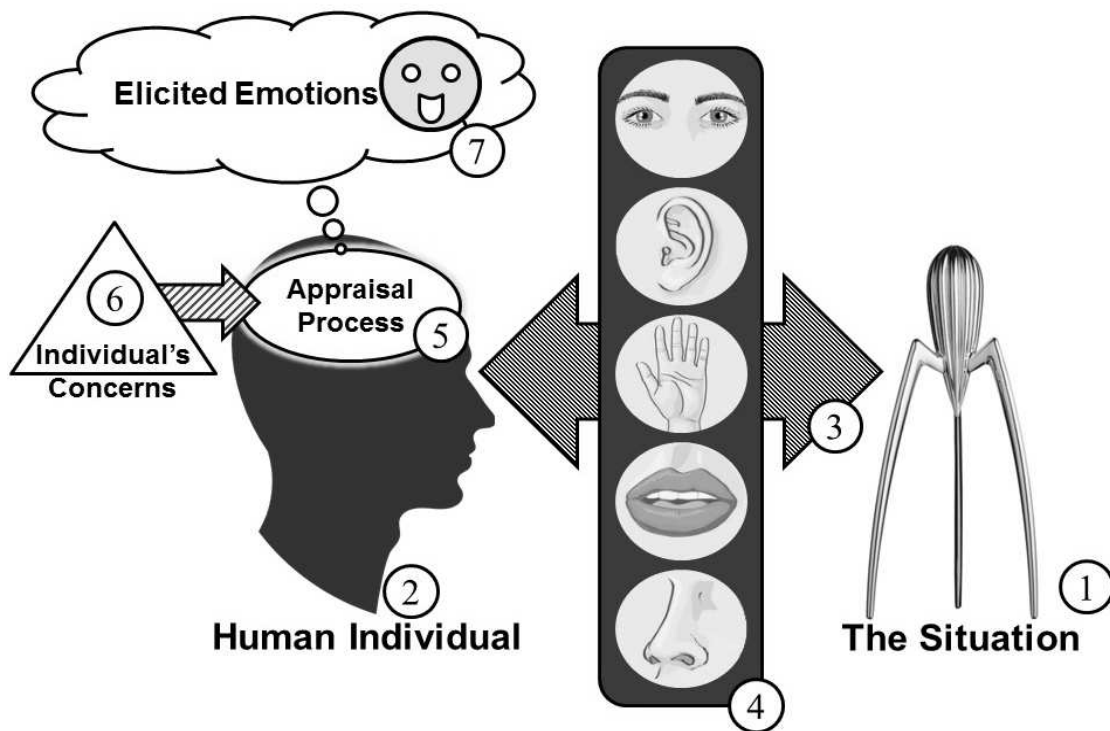

Figure 6: The appraisal process in human emotion elicitation

A pre-requisite of the process of emotion elicitation is that the human individual (2) must interact (3) with the situation (1) which is perceived by the individual via the human senses (4). The human senses (4) act as the medium through which the interaction (3) takes place. The perceived situation undergoes a process of appraisal (5). Throughout this process the situation is appraised with respect to the concerns of the individual (6). In the context of product development the concerns of the individual workers may include: concerns about the individual's health and safety, concern about having the right tools and resources necessary to execute the required tasks and the concern about having a comfortable and visually appealing work environment. The type of emotions (7) elicited depend on the extent to which the situation is evaluated as being relevant, a threat or benefit with respect to the individual's concerns (6).

The appraisal theory explains why different, if not contrasting, emotions may be elicited from individuals who interact with the same identical situation. This is due to variation in the concerns of individuals. A particular situation may be appraised to be a threat to the concerns of an individual thus eliciting negative emotions. The same identical situation may be appraised as beneficial to the specific concerns of other individuals, hence more positively toned emotions are elicited.

The decisions made during the early stages of product design have ramifications on the multiple meetings between the individual and other life-phase systems which constitute the situation (1) shown in Figure 6. The illustration in Figure 7, provides a simple but important taxonomy of different types of life-phase systems which embody the situation. In this taxonomy life-phase systems are divided in two broad categories: natural and artificial. Some examples of artificial systems include fabrication systems such as a drill press, the artefact itself and a material handling system. The natural system category is comprised of human workers who execute tasks on the evolving artefact and the customers who interact with the finished product during the use phase. The important reflection emerging from this taxonomy is that the differentiating factor between the two systems is that while artificial systems

have only a physical state (PS), natural systems have both a physical and an affective/emotional state (AS).

As reflected from the literature review presented, current research has focused on the influence which the physical state of the artefact has on the emotions elicited from human users. For example, the design for assembly guidelines (DfA) typically require for the form and dimensions of the artefact to be altered in such a way as to improve the meeting between the constituent components and the assembly equipment.
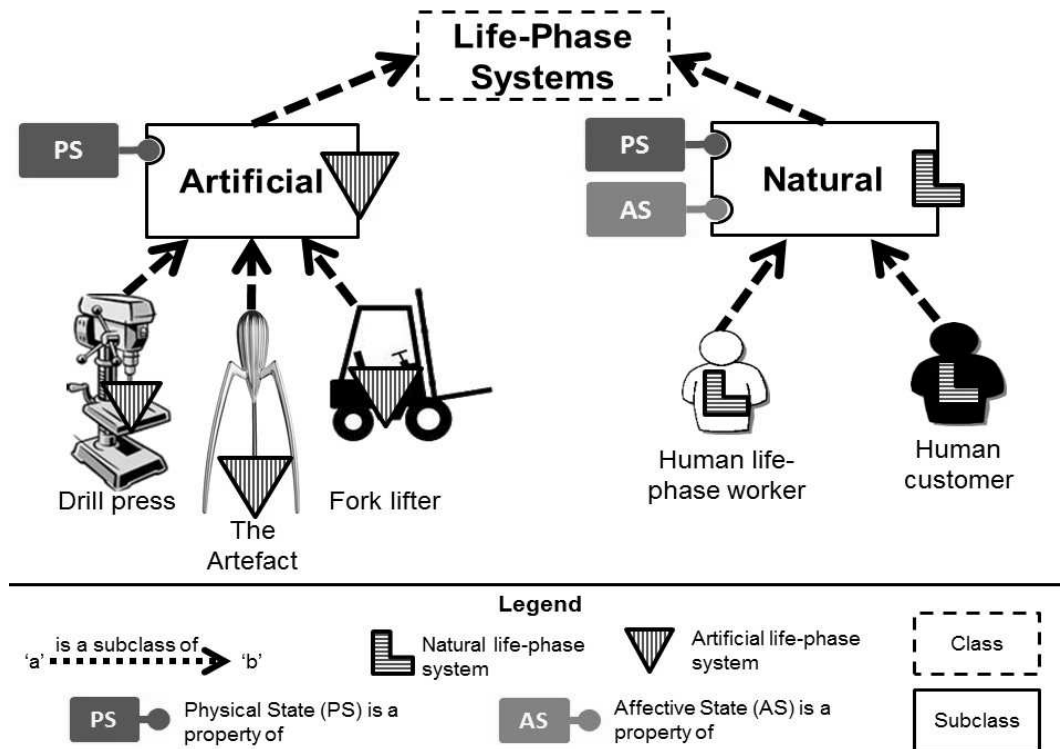

Figure 7: A simple life-phase system taxonomy

Unlike artificial systems, natural systems provide the opportunity for stakeholders to improve product development by influencing not only their physical state but also their affective/emotional state. The underlying principle behind the research presented in this paper is that in addition to artificial systems, stakeholders may improve product development by considering the emotions elicited as a result of the interaction involving the human workers with other natural and artificial systems

This section has outlined the shortcomings of literature pertaining to product design and human emotions. The main critique of the reviewed literature is that current research performed focused on user emotions and has failed to consider the emotions elicited from human workers. In addition the section also explained the appraisal process which is responsible for the elicitation of human emotions. This section also provided a simple taxonomy of the life-phase systems which constitute the situation with which the individual interacts.

3   THE RELEVANCE OF HUMAN WORKER EMOTIONS TO PRODUCT DEVELOPMENT

This section aims to answer the following questions: (i) what is the relevance of worker emotions in the context of product development? (ii) why does handling worker emotions contribute to the improvement of product development? For this reason, this section will present existing literature together with an empirical study that will provide evidence in sustaining that handling worker emotions may indeed contribute to improve product development.

One of the effects which result from the elicitation of worker emotions is the change in behaviour of the individual. Numerous studies [Bashir, 2010; Chandhok & Monga, 2013; Dar, Akmal, Naseem, Ud, & Khan, 2011; Qureshi, Iftikhar, & Abbas, 2013; Shikieri & Musa, 2012] have consistently shown

that the elicitation of stress related emotions have a negative influence on individual's job performance. In addition, the elicitation of negative emotions at work can also result in workers who actively engage in counterproductive work behaviour [Spector, Fox, & Domagalski, 2006; Yang & Diefendorff, 2009] towards other individuals within the organization and the organization itself.

A limitation of the aforementioned research is that it does not consider the influence of the elicited emotions on the performance of human workers from a product development perspective. For this reason, part of the ongoing research work was to conduct semi-structured interviews with 60 human operators from 4 different manufacturing firms. Throughout these semi-structured interviews, the operators were asked to complete a survey questionnaire. The interviewees were asked to rate the extent to which they considered the experience of negative stress emotions to hinder their productivity. A 5 point Likert scale was used due to its inherent ability to offer a compromise between resolution of responses and lack of ambiguity. The responses obtained for each question are summarized in Table 2.

The first column on the left of Table 1 shows the statement and its corresponding Likert score while the second column shows the frequency of response for each point on the Likert scale. The third column shows the frequency as a percentage of the total respondents while the fourth and fifth column show the standard deviation of the responses and the average score.

Table 2: Responses pertaining to the influence of negative emotions on productivity

Q: To what extent do you consider the elicitation of negative stress emotions to influence the productivity of your work output?				
Likert Scale (numerical score)	Frequency of Response	Percentage of Respondents (%)	Standard Deviation	Average Score
Very Ineffective (1)	2	3.33		
Ineffective (2)	2	3.33		
Neutral (3)	1	1.67	0.933	4.33
Effective (4)	24	40.00		
Very Effective (5)	31	51.67		

The average score obtained was 4.33 out of a maximum possible score of 5.00. This indicates that the corresponding average response on the Likert scale was effective tending towards very effective. In fact 40.00% of the participants considered the elicitation of negative emotions to be effective in influencing their productivity while a sheer 51.67% of respondents considered the elicitation of negative emotions to be very effective in influencing their productivity.

Throughout the study, the interviewees were also asked to rate the extent to which they considered the elicitation of negative stress related emotions to influence the quality of tasks executed. The responses which were recorded throughout the semi-structured interview are summarized in Table 3.

Table 3: Responses pertaining to the influence of negative emotions on the quality of work executed.

Q: To what extent do you consider the elicitation of negative stress emotions to influence the quality of the tasks that you execute?				
Likert Scale (numerical score)	Frequency of Response	Percentage of Respondents (%)	Standard Deviation	Average Score
Very Ineffective (1)	0	0.00		
Ineffective (2)	2	3.33		
Neutral (3)	13	21.67	0.880	4.15
Effective (4)	19	31.67		
Very Effective (5)	26	43.33		

The results show that 75.00% of the respondents considered the elicitation of negative emotions to be detrimental to the quality of the tasks which are executed. On several occasions the interviewees pointed out that whenever experiencing negative emotions they notice an increase in the portion of components which are rejected during quality inspections.

In both cases the distribution of the responses that was obtained was surprising in view of the existence of a social desirability bias [Ian, 2004; Norman, Seymour, & Brian, 2004]. This bias occurs whenever participants provide responses with the aim of presenting a more socially acceptable image of themselves to the interviewer. In the case of this empirical study, the respondents were asked to rate the extent to which they considered the elicitation of negative emotions to influence their work performance. Despite the existence of this bias, the majority of the respondents still claimed that the elicitation of negative emotions has indeed a negative influence on their productivity and the quality of tasks being executed.

This section has presented the results obtained through an empirical study carried out with the intent to investigate the extent to which negative emotions are considered to influence the job performance of human workers. The results indicate the elicitation of negative stress related emotions such as anger and dissatisfaction, have undesirable ramifications on the performance of human workers both in terms of the quality of tasks and productivity. The questionnaire responses suggest that the elicitation of negative worker emotions may indeed contribute to lengthen product development time and increase costs due to a decrease in productivity and a deterioration in the quality of work which is executed. The next section of the paper provides an insight toward handling worker emotions with the intent of improving product development.

4 TOWARDS HANDLING WORKER EMOTIONS: UNDERSTANDING THE CONCERNS OF HUMAN WORKERS

A human emotion is the result of an appraisal of the situation with respect to the individual's concern. It follows logically, that in order to handle worker emotions, one must first understand what the concerns of human workers are. The section presents the second part of an empirical study saw the participation of 60 human workers. The objective of this part of the study was to understand what the concerns of human workers are. The results obtained throughout this section of the survey questionnaire are summarized in Table 4.

Throughout the survey questionnaire the participants were presented with a list containing 8 statements representing a variety of concerns based on previous literature [Bashir, 2010; Jo, 1992; Qureshi et al., 2013]. The participants were required to provide an exclusive rank for each statement by assigning a score in the range of 1 to 8 both inclusive. A rank score of 8 represented the most important concern while a rank score of 1 represented the least important concern.

The first column on the left of Table 4 contains the list of concerns which were presented to the interviewed subjects. The second column contains the rank score frequency distribution, which indicates the number of times a particular statement obtained a particular rank score. For example the statement 'minimize the work overload on myself' was given a rank score of seven, three times and a rank score of three, twenty-two times.

The third column in Table 4 represents the average rank score, which denotes the relative importance of each statement. This means that the concern 'my health and safety' was considered to be the most important concern with the highest average rank score value of 448.00. The least important concern was represented by the statement 'spending as much time as possible away from work' with an average rank score of 107.30.

The results of respondents in Table 4 as obtained from the each of the 4 manufacturing firms are illustrated Figure 8. The plot in Figure 8 shows that the appearance and the comfort of the work environment was a concern that was ranked in the fourth place. This was due to the fact that most of the operators work in eight hour long shifts. One attribute that was mentioned very frequently by the participants to contribute in rendering the physical work environment less comfortable was the excessive ambient noise emanating from the operation of tools and machines.

Table 4: Ranking of human worker concerns

Statement representing concern	Rank Score Frequency Distribution (8 – Highest Rank, 1 – Lowest Rank)								Average Rank Score
	8	7	6	5	4	3	2	1	
spend time away from work	0	1	1	1	1	9	29	18	107.30
being very productive	0	1	1	1	13	4	13	27	108.45
minimize work overload	0	3	0	6	8	22	12	9	173.15
building positive relationships with colleagues	5	4	11	8	1	11	2	4	271.07
the comfort and appeal of the work environment	4	11	8	13	15	6	2	1	304.02
the quality of work carried out	9	11	13	19	3	4	1	0	348.00
being provided with adequate work resources	1	19	21	11	5	2	1	0	350.00
my health and safety	42	10	5	1	1	1	0	0	448.00

The concern of having a comfortable and visually appealing work environment was followed very closely by the concern of building strong positive interrelationships among other co-workers. This was a particularly important concern in the case where the respondent was required to interact with the same co-worker on a daily basis.

The concerns considered to be of less importance were: minimizing the work overload, being extremely productive irrespective of the quality of work that is executed and spending as much time as possible away from work.
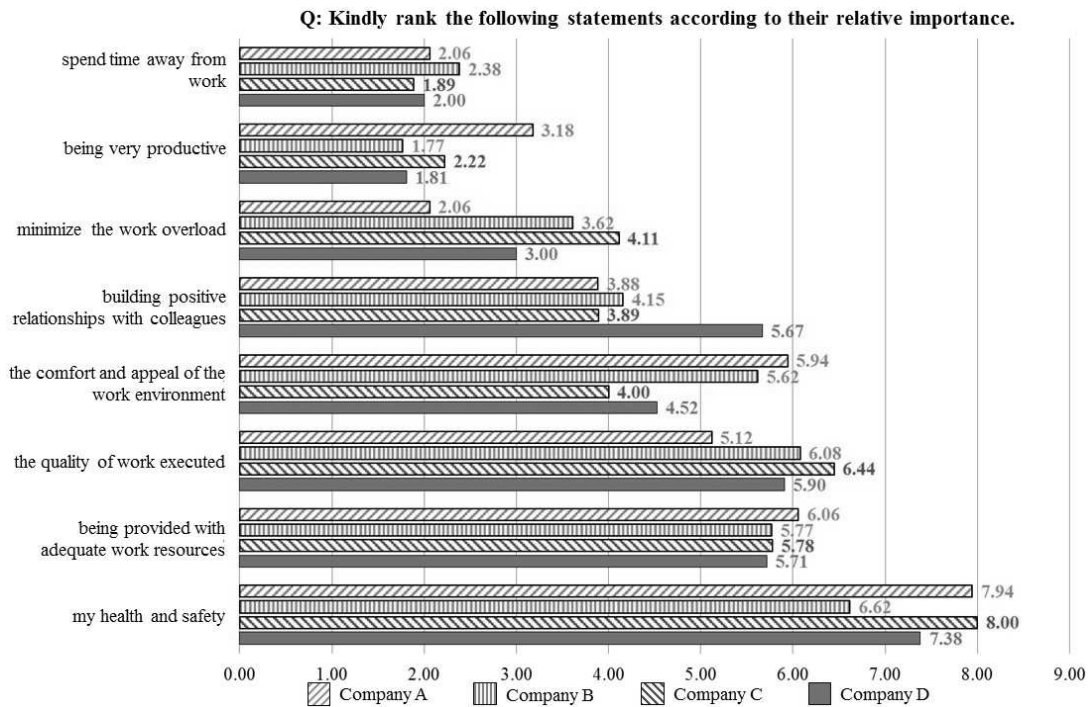

Figure 8: Ranking of Worker Concerns

The shape of the plot illustrated in Figure 8 suggests that the ranking of concerns from individual workers within 4 distinct manufacturing firms was fairly consistent. There is in fact a common hierarchy of concerns which is shared among the interviewed participants. At the bottom of this hierarchy one finds the most elemental and important concerns such as the concern for personal health and provision of the necessary work resources. Strong negative emotions are elicited in the case where the situation is appraised by the human worker to present a threat to these concerns. The strength of the emotions elicited decreases the further up one goes in the hierarchy. For example the concern to minimize the work overload on myself and/or my colleagues will elicit relatively weak emotions, due to the fact that this emotion near the top of the hierarchy.

4.1 The Significance of the Hierarchy of Concerns to Product Development

The hierarchy of concerns illustrated in Figure 9 provides an insight to product development stakeholders as to what are typical concerns shared among human workers and how these concerns are prioritized.
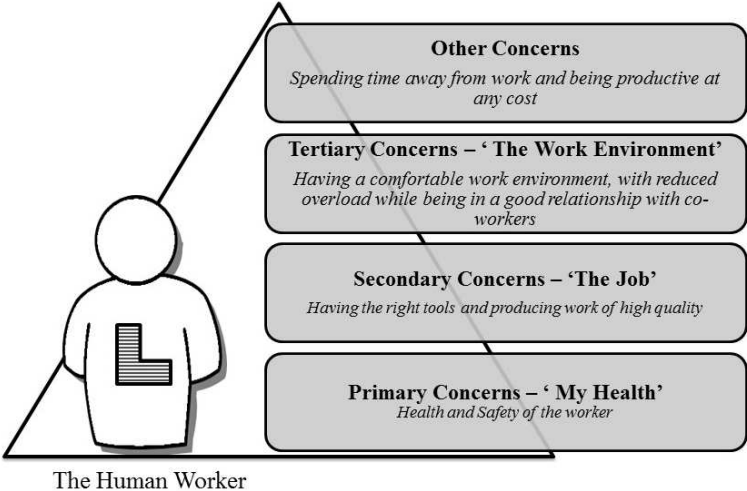

Figure 9: A model for the concerns of human workers

This insight contributes towards guiding stakeholders into making product development decisions which do not elicit undesirable emotions from human workers. For example the decision by product designers to use a particular product colour may result in the elicitation of negative emotions from human workers who meet with the artefact during its visual inspection. The decision pertaining to the colour of the product renders the task of conducting visual inspection more difficult. As a result the meeting between the artefact and the human worker has the unforeseen consequence of eliciting negative emotions such as anger and frustration. In this case the choice of product colour threatens the concern of the human worker which is that to conduct the expected tasks correctly.

Another example is the decision of manufacturing stakeholders to rapidly cool soldered components using powerful air blowers which are situated in the vicinity of human workers. In this case the meeting between the human workers and the air blowers has the consequence of eliciting negative emotions. This is due to the fact that the constant high noise levels emanating from the blowers threatens the concern of workers which is to operate in a comfortable physical work environment.

The fact that the concerns are structured in a hierarchy which denotes their relative importance, enables product development stakeholders to make effective decisions which do not elicit strong negative emotions. The empirical work presented in this paper provides evidence to sustain that failure to address the most important worker concerns, results in the elicitation of strong negative emotions which in turn is manifested in a decrease in the productivity and a deterioration in the quality of tasks being executed. It follows that by considering the hierarchy of concerns product development stakeholders will be in a better position to effectively handle worker emotions which as a consequence contributes towards ameliorating product development.

5   CONCLUSIONS

The paper outlined the research work undertaken with the intent of exploiting the emotional state of human workers in order to improve product development. The literature review presented in section 2 suggests that research into human emotions and product development has so far been limited to the emotions elicited from human customers during the use phase. To this extent the main critique of the reviewed literature is that research into product development and human emotions should assume a broader view, as to include the emotions of human workers who are responsible for the fabrication and assembly of the evolving artefact.

Based on this gap in the body of literature, the paper proceeded with presenting an empirical study that saw the participation of human workers from four distinct manufacturing firms. Based on the responses obtained from this study, the following conclusions may be made:

(i). The first part of the empirical study presented in section 3 provides evidence to sustain the notion that the elicitation of negative emotions is considered to have substantial ramifications on the productivity and quality of tasks which are executed. This may contribute to increase development and product costs and lengthen the product development process. The results obtained suggest that handling worker emotions in the context of product development may indeed contribute to ameliorate the product development process.

(ii). The elicitation of an emotion is the result of the individual's appraisal of the situation with respect to his/her concerns. The results obtained from the empirical study suggest that the interviewed subjects do in fact share a hierarchy of concerns. The hierarchy denotes the relative importance of each concern, where the most important concern results in the elicitation of strong negative emotions when threatened.

The empirical research results presented in this paper suggest that product development stakeholders should consider the influence of product development decisions on the emotional state of human workers. This is due to the fact that the responses obtained from the interviewed subjects lead to the conclusion that the elicitation of negative emotions from human workers may in fact contribute to increase costs, development time and reduce the quality of the product being developed. The research has also provided an insight on the structure of the concerns which are shared among human workers. The hierarchy of concerns is the first step towards providing support to product development stakeholders in handling worker emotions with the intent to improve product development.

The short term goal of the research is to identify what are the product development decisions which have the greatest impact on the concerns disclosed in this paper. This will enable the research to establish a complete model which maps the product development decisions to the concerns of human workers. The long term goal of the research work is to develop a means with the intent of enabling product development stakeholders to foresee the influence of the decisions made on the emotions elicited from human workers.

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