Pupils' Emotional Experience in Human-Technology Interactions

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The experience of human emotion is a central topic in the research field of product design and human interactions. Emotions have the ability to affect pupils' experience deeply since the elicitation of emotion has the ability to affect attention, behaviour and attitude towards man-made artefacts. The qualitative study presented in this paper is part of ongoing research intended to develop a framework for modelling pupils' emotional experiences when interacting with technological artefacts. This paper underlines how the elicitation of emotion is itself a consequence of the interaction between the human individual and the technological artefact. These conceptualisations underline the necessity to study the attributes both human and technological artefacts responsible for the elicitation of emotion. The study presented in this paper focuses on the human element. The participants in this study were students undertaking an undergraduate programme in technical design and technology offered by the Department of Technology and Entrepreneurship Education at the University of Malta. The study reveals that 43% of the subjects are concerned with being provided proper guidance and mentoring particularly when interacting with technological artefacts which are novel to the pupils. In addition, the study reveals that the inherent simplicity of a technological artefact and the ability to provide an immediate visual feedback, as factors which contribute to render the interaction between pupils and technological artefacts more enjoyable. The results emerging from the empirical study are discussed in light of how pupils' concerns and emotional experiences influence attitudes towards technological artefacts.

Keywords: Attitude, Emotion, Technology, Design, Education

Introduction

Research in user experience has received increasing attention in numerous domains such as industrial design, engineering and education (Chiu & Ho, 2013; Lee Do & Schallert, 2004; Pekrun et al., 2007; Smith & Smith, 2013). The framework proposed by Desmet and Hekkert (2013) identifies the three components which constitute user experience. According to the authors (Desmet & Hekkert, 2013) emotions play a central role in shaping the experience of an artefact by its users. It has also been demonstrated that human emotion has the ability to influence the behaviour (Wright et al., 2002; Yang & Diefendorff, 2009), work performance (Farrugia & Borg, 2014) and purchase intention (Soodan & Pandey, 2016) of the individual.

Pupils' emotions and attitudes have also been a central theme in education research. The research has been motivated by evidence (Pekrun et al., 2007, 2011; Tyng et al., 2017) pertaining to the influence of emotions and attitudes on the learning process. Emotions play a central role in education (Pekrun et al., 2011) since learning and achievement are inherent characteristics of educational activities and major sources of emotions. Positive emotional experiences, such as joy and pride, have a significant effect on pupils' motivation and effort (Colomeischi & Colomeischi, 2015; Pekrun et al., 2002).

Pupils' emotional experiences are influenced by a multitude of factors which are categorized as being internal and external (Pekrun et al., 2002). Internal factors refer to individual differences between pupils such as values, goal hierarchies and expectations. External factors are often associated with the classroom environment, quality of the classroom instruction as well as feedback. It has been shown that

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internal factors such as the perception of ability and achievement motivation (George, 2006; Salminen-Karlsson, 2007) influence pupils' attitudes towards science and technology.

Technological literacy has increasingly become an important aspect of education as it prepares students to adequately address challenges in a modern knowledge economy (Czaplinski et al., 2015; Kimbell & Perry, 2001) and in consequence enhance their employability (Carnevale et al., 2011). An important factor which determines technological literacy of a pupil is the attitudinal dimension (Ardies et al., 2014). This aspect is very important particularly in relation to evidence suggesting that the opinions of young pupils on education and careers in technology are not positive (Johansson, 2009). The measurement of pupil's attitudes has been a salient theme in the domain of research in technology education. The Pupils Attitudes Towards Technology (PATT) (Raa, J. et al., 1988) instrument was developed and has since been widely used to measure pupils attitudes towards technology in the context of education.

Emotions and Attitude

The term attitude refers to a broad concept with a plethora of definitions having been proposed throughout the decades (Banaji & Eiphets, 2010; Bohner & Dickel, 2011). Attitudes have been defined as representing an evaluative integration of cognition and affect in relation to an object (Crano & Prislin, 2006). Another definition is that attitude is an evaluative judgment based on cognitive beliefs and its evaluative aspect (Agarwal & Malhotra, 2005). One of the most widely accepted definitions is that an attitude is an evaluation of an object of thought with some degree of favour and disfavour (Eagly & Chaiken, 1993). Despite the numerous definitions (Breckler, 1984; Kothandapani, 1971; Rosenberg & Hovland, 1960), the evaluative aspect is a persistent characteristic which is shared among the different definitions of the attitude concept.

Emotions and attitudes share a common characteristic, which is that they are both evaluative in nature. Richard Lazarus (1999) underlined how human emotion is the result of a mental evaluation process, whereby the individual assesses the nature of a stimulus and the potential to cope with it. The cognitive appraisal theory of emotions was developed by Scherer (2001) and is a widely accepted explanatory theory pertaining to the cognitive processes of emotions. This theory views the elicitation of human emotion as the result of sequential checks whereby the individual evaluates the nature and significance of a stimulus or event in relation to concerns representing beliefs, goals and motivations.

Owing to the similarities between attitude and emotions, attempts have been made to integrate the literature pertaining to the two concepts. One approach has been to treat the emotion as an antecedent of one's evaluation of the attitude object (Zanna & Rempel, 1988). In other words, positive (or negative) emotions serve as an antecedent to the favourable (or unfavourable) attitude judgement towards an object such as a technology artefact. A study (Allen et al., 1992) showed that the effect of emotions on behaviour can at time be mediated by attitude judgments. Rosenberg and Hovland (1960) suggested that the attitude about an object consists of how we feel, what we think an what we are inclined to do. This three-component theory has also been supported by empirical-based evidence (Breckler, 1984; Pooley & O'Connor, 2000). This three-component model was revised and adopted by Van Aalderen-Smeets et al. (2012) in a framework for describing and researching the attitudes of primary teachers towards the topic of science and the teaching of science.

The research presented in this paper focuses on the emotional component of attitude. The focus on the emotional component is substantiated by evidence showing that emotional experiences are central in learning and have the capacity to influence pupils' behaviour and motivation (Pekrun et al., 2002). The foundation for understanding emotions elicited from pupils is based upon the cognitive appraisal theory of emotion which was proposed by Scherer (2001). A key strength of this theory is that accounts for internal factors (e.g. individual differences) as well as external factors (i.e. different stimuli) which collectively determine the emotional response. Stemming from this definition, there are two elements which collectively determine the emotional response: the concerns of the individual and the properties of the technological artefact with which the human being interacts. With reference to Figure 1, the emotion experienced by an individual can be viewed as a consequence of the meeting between the technological artefact and the human who has specific concerns (Farrugia & Borg, 2016). During this meeting, the human individual evaluates the relevance and significance of the technological artefact in relation to specific concerns. Hence the concerns are analogous to evaluation criteria which determine the type of emotion elicited. During this meeting, the human individual evaluates the relevance and significance of the technological artefact in relation to specific concerns. Hence the concerns are analogous to evaluation criteria which determine the type of emotion elicited.

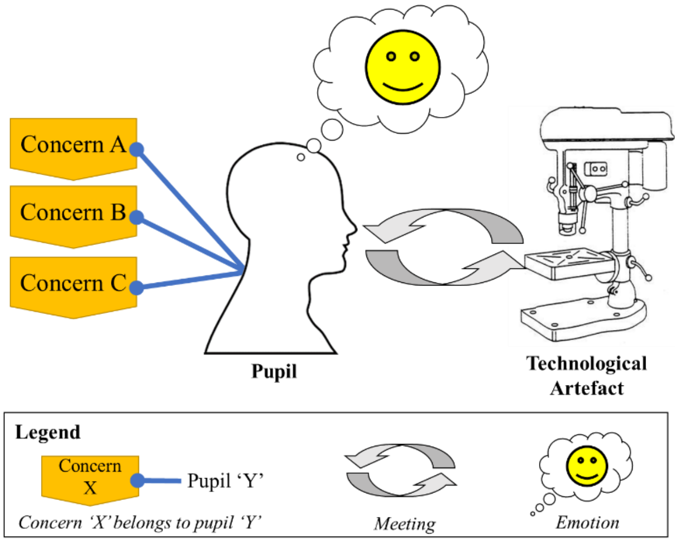

Figure 1. Emotions as consequence of human-artefact meetings

Empirical Study

The main argument presented in this paper is that pupils' attitudes and behaviour towards technology can be better understood by investigating their emotional experience. The objective of this exploratory study was to identify several concerns of first and second-year undergraduate students (N=7) enrolled in a three-year Bachelor of Science (B.Sc.) degree in Technical Design and Technology. The sample is representative of the entire population of students undertaking the undergraduate B.Sc. degree in Technical Design and Technology. In this respect our sampling strategy was purposive, based on convenience and representative. Due the limited sample size, the authors of this paper acknowledge that the conclusions derived from this study cannot be generalised, however these provide a first step towards exploring concerns, technological factors and pupils' attitudes and emotions towards design and technology. Furthermore, owing to the limited sample size the exploratory study will not consider the effect of pupils' gender and age on concerns and attitudes towards technology.

Methodology

Based on the definition of emotion adopted in this paper, a semi-structured one-to-one interview with the participants was carried out with the intent to identify: (i) the relative importance of pupils' concerns and (ii) the technologies which pupils consider to be the most and least enjoyable. During the interview the interviewer outlined the purpose of the study and explained the items which constituted the paper-based questionnaire used during the interview. A reason for administering the questionnaire in a one-to-one interview was to alleviate social desirability bias (Bradburn et al., 2004). In addition, a face-to-face interview enabled the researcher to directly address subjects' queries and provide clarifications pertaining to specific statements in the questionnaire (Cohen et al., 2018). This approach ensured that the subjects interpreted the questions as intended.

During the interview, the participants were asked to carefully read and rank a list of statements representing a wide array of concerns. These statements were formulated based on prior observations by lecturers' delivering practical and taught elements of the B.Sc. in Design and Technology, to pupils interacting with technological artefacts such as electronic and fabrication equipment in laboratory and workshop environments. The statements were also derived from prior research work in the realm of manufacturing engineering (Farrugia & Borg, 2016). Subjects were also encouraged to include additional statements representing alternative concerns not represented in the list. Upon discussing each statement, the participants were allocated sufficient time to rank each individual statement according to its relative importance.

Subsequently the focus of the interview was shifted towards the assessment of different technologies in terms of enjoyability. The participants were presented with a non-exhaustive list of technologies which are typically employed during workshop and laboratory sessions of the undergraduate course. During the interview the subjects were asked to select up to three technologies which they had enjoyed interacting with and provide reasons for their choice. Similarly, the participants were also asked to identify three technologies which they did not enjoy using and also provide reasons for their choices. The participants responses and the reasons provided during the interview were recorded on the questionnaire.

Results and Discussion

Out of the seven subjects (N=7), only one student was female with the rest being male. The age of all the participants was less than or equal to twenty years. As outlined in the previous section an objective of this study was to identify the relative importance of students' concerns. These concerns are analogous to the criteria used during the evaluation of a stimulus such as a technology artefact and hence play an important role in determining the emotion component of attitude judgements.

The concerns presented to participants are listed in the first column of Table 1. The mean rank score (μs) in the second column represents the average rank order obtained by each statement. Statements which represent concerns considered to be the most important are those which have the lowest mean rank score (μs). The relative importance of each concern is also denoted by an overall rank which can be referred to in the fourth column of Table 1.

The results show that 43% of the participants consider being provided with proper guidance and mentored by a knowledgeable person to be the highest-ranking concern. The discussions which ensued during the interview revealed that pupils are compelled to learn about a novel technological artefact particularly if they are mentored by a technically knowledge individual. Several participants underlined the importance of this concern particularly due to the fact that their interaction with several technologies was novel.

This concern is closely related to the fourth highest-ranking concern ($\mu s = 5.429$) presented in Table 1 which refers to the complexity of the technological artefact itself. The interview also revealed that subjects are motivated to learn and interact with a technological artefact if it is not exceedingly complex to use and is characterised by a gradual learning curve. The responses suggest that in addition to proper guidance, pupils tend to prefer interacting with technological artefacts characterised by simple operating principles such as a manually operated pillar drill instead of more complex machines such as a computer numerically controlled (CNC) machine. With reference to electronics a subject stated that:

The learning curve was too great to begin with. I feel that too much was expected in little time.

The simplicity and relevance of technological artefacts coupled with proper mentoring collectively contributes to a gradual learning curve.

Table 1. List of concerns sorted by ranking score

Statement of a concern with respect to technology	Mean Rank Score μ_s	Overall Rank
The technology is utilized under the supervision of a knowledgeable person and followed by proper guidance	2.714	1
The technology being used is of relevance to my career	3.333	2
The technology has minimal safety risks associated with it	4.143	3
The technology is not technically complex and demands a gradual learning curve	5.429	4
The technology is reliable with seldom breakdowns	5.571	5
The technology is fit for the purpose it is being used	5.714	6
The technology being used is not old and/or outdated	5.857	7
The technology is not tedious to use	6.714	8
The technology is used in a comfortable and aesthetically pleasing environment	7.286	9
The technology has a minimal negative impact on the environment	8.571	10

The second highest-ranking concern pertains to the relevance of the technology to the career being pursued by subjects (µs = 3.333,). The discussion during the one-to-one interviews revealed that the several participants are motivated to learn and use a technological artefact if this is perceived to be of relevance to their careers. Subjects also ranked highly the concern pertaining to their health and safety (µs = 3.333). This result shows that pupils' attitude judgements towards a technological artefact are also influenced by their perception of the safety risks associated with the technology being used. During the face-to-face interviews, subjects expressed their concern about their health and safety and how they would be reluctant to interact with technological artefact if they perceive threats to their well-being.

The interview also served to identify the technologies which students consider to be enjoyable. The results disclosed in Table 2 provide a cross-section of the various technologies and how these were ranked by participants in terms of their enjoyability.

Table 2. Ranking of technologies in terms of enjoyment

Technology	Percentage (%)	Overall Rank
Electrically powered and manually operated fabrication tools/equipment e.g. lathe, pillar drill, milling machine etc.	22	1
Manually powered and operated fabrication tools/equipment e.g. hand drill, saw, rasp etc.	17	2
Computer-Aided Design software e.g. AutoCAD, Sketchup etc.	17	2
Computer Numerically Controlled machines e.g. CNC milling,	11	4
Manual draughting tools	11	4
Interactive technologies e.g. Augmented reality, virtual reality etc.	11	4
Assembly equipment e.g. welding, brazing, soldering etc.	6	7
Electronic components e.g. breadboard, capacitors, oscilloscope	6	7
Programmable logic controllers e.g. Arduino, Raspberry etc.	0	9
Programming platforms e.g. Python, C++, Java, etc.	0	9
Textile technologies e.g. sewing machine, stitching etc.	0	9

During the design of the questionnaire, an important distinction was made between tool-based, machine-based and automated manufacturing technologies (de Vries, 2016) such as manually operated hand drill, pillar drill and a CNC machine respectively. While these technologies can achieve the same outcomes (e.g. the creation of a hole feature), they vary significantly in terms of how the pupil interacts with the technological artefact and the degree of control which the pupil has over the transformation process. For example, tool-based (e.g. hand drill) and machine-based (e.g. pillar drill) technology afford the pupil complete and direct control over the machining (transformation) process. This requires the student to understand well the operating principle of the technology in order to achieve the desired outcome (e.g. a drilled hole of the correct dimensions). On the other hand, an automated machine such as CNC drill presents a different type of learning opportunity as the machining process itself is carried out by the (automated) machine. In this case, the pupil has to understand the programming language used to convey instructions executed by the CNC machine. The results disclosed in Table 2 show that the highest-ranked technologies were electrically operated and manually operated fabrication tools such as pillar drills, lathes, milling machines and cutting tools. A reason which was shared by several participants was that a technological artefact is considered enjoyable if it provides immediate and visual feedback. During the interview one of the participants stated that:

> I enjoy to see the process of the material being machined and watching it come together.

Another subject noted that:

> Using the lathe was a very interesting insight into manufacturing of various parts, while allowing for creative freedom.

In this sense, pupils enjoy using manual and machine-based tools because these provide an immediate feedback to the pupil's input. An ulterior reason which was shared by several participants is the sense of self-fulfilment, particularly when pupils have direct control over the creation of physical objects from raw materials using tool-based and machine-based equipment. The emotion of pride is an important consequence which is elicited from pupils when interacting with technological artefacts such as lathes and pillar drills, particularly since these tools provide an immediate visual feedback.

The results in Table 3 provide a ranking of the various technologies in terms of least enjoyable. The results show that by far and large the interaction with electronic components such as breadboard, capacitors and oscilloscope were ranked as the least enjoyable.

Table 3. Ranking of technologies in terms of least enjoyment

Technology	**Percentage (%)**	**Overall Rank**
Electronic components e.g. capacitors, oscilloscope etc.	43	1
Programmable logic controllers e.g. Arduino, Raspberry etc.	14	2
Computer-Aided Design software e.g. AutoCAD, Sketchup etc.	14	2
Interactive technologies e.g. Augmented reality, virtual reality etc.	14	2
Textile technologies e.g. sewing machine, stitching etc.	14	2
Manually powered and operated fabrication tools/equipment e.g. hand drill, saw, rasp etc.	0	6
Electrically powered and manually operated fabrication tools/equipment e.g. lathe, pillar drill, milling machine etc.	0	6
Computer Numerically Controlled machines e.g. CNC milling,	0	6
Assembly equipment e.g. welding, brazing, soldering etc.	0	6
Manual draughting tools	0	6
Programming platforms e.g. Python, C++, Java, etc.	0	6

A reason which was shared by several participants is the fact that these technologies do not provide immediate feedback. One of the participants commented that a delay between building and feedback provided by a working the circuit as a primary reason for not enjoying working with electronic components. Hence when building an electronic circuit, the pupil must build the entire circuit before he/she can verify if the circuit works. The lag which exists between pupils' input and the feedback provided to the student by the technology (e.g. electronic circuit works) renders the technology frustrating to use and hence pupils express a negative attitude judgment towards the technology. Another participant mentioned the diagnosis process as the only reason for not enjoying interacting with electronic components.

Another reason which was provided by several subjects is that electronic circuits and components constitute no moving parts and in consequence are difficult to visualise. To this end activities such as designing and root-cause analysis were considered to be more difficult as these require a higher level of abstract thinking. In relation to the concerns reported in Table 1 one of the students noted that the reason for not enjoying using electronics was the steep learning curve.

Conclusion

Human emotion can be considered as a consequence of the interaction between the human pupil and the technological artefact and is shaped by two factors: individual differences and the characteristics of the technological artefact itself. Based on this theoretical foundation the paper presented an exploratory study intended to gain a better a better understanding of the concerns and technological factors which collectively shape pupils experience and attitude judgements towards technology.

The paper presented a study which was undertaken to investigate the concerns and preferences towards technological artefacts of pupils who are currently reading for an undergraduate degree in Design and Technology. The evidence collected from the limited but representative sample reveals that some concerns were consistently ranked as being more important than others. The evidence suggests that pupils are keen to learn and make use of a technology given that they are provided with adequate knowledge and mentored by a knowledgeable individual. A reason for this concern is in part due to the fact that pupils are also concerned with their health and safety when interacting with a technological artefact. Hence the provision of knowledge and a technically knowledgeable person would contribute to attenuate the safety risks involved.

The ranking of technological artefacts and the reasons provided were in line with the way in which the concerns were ranked by the interviewed subjects. For example, the study revealed that pupils are highly concerned with the overall complexity and learning curve inherent to a technological artefact. A reason for this result is that for many pupils the interaction with technological artefacts such as hand-based and machine-based technology in most cases is novel. An ulterior reason for the preference towards hand-based and machine-based technological artefacts is that these tend to be based on rudimentary mechanical engineering principles and can provide an immediate visual feedback to pupils' inputs. This is unlike technological artefacts such as electronic circuits which were consistently characterised as unenjoyable due to the delay which exists between building a circuit and its operation. Furthermore, the technological artefacts which were consistently ranked as unenjoyable tend to difficult to visualise and require a certain level of abstract thinking and diagnosis. This characteristic is in contrast with the concern of being provided with technological artefacts do not impose a steep learning curve on the pupil.

Based on the evidence from the limited yet representative sample it may be concluded both technological factors and human concerns contribute to shape pupils' attitude judgements and experience. The exploratory study presents a first step towards the development of guidelines intended to aid stakeholders responsible for the development of educational programmes in the realm of design and technology. The aim of these guidelines would be to help stakeholders foresee the impact of decisions such as the selection of technological artefacts, on the attitude judgments and learning experience of pupils.

Future Research

An evident limitation of this study was the number of subjects who participated in the study. To this end, the purpose of the research work in the future would be to extend the study to include more students. An interesting approach would be to investigate the concerns and preferences of design and technology educators.

References

Agarwal, J., & Malhotra, N. K. (2005). An integrated model of attitude and affect: Theoretical foundation and an empirical investigation. *Journal of Business Research*, *58*(4), 483–493. https://doi.org/10.1016/S0148-2963(03)00138-3

Allen, C. T., Machleit, K. A., & Kleine, S. S. (1992). A Comparison of Attitudes and Emotions as Predictors of Behavior at Diverse Levels of Behavioral Experience. *Journal of Consumer Research*, *18*(4), 493. https://doi.org/10.1086/209276

Ardies, J., De Maeyer, S., Gijbels, D., & van Keulen, H. (2014). Students attitudes towards technology. *International Journal of Technology and Design Education*, *25*(1), 43–65. https://doi.org/10.1007/s10798-014-9268-x

Banaji, M. R., & Eiphets, L. (2010). Attitudes. In *Handbook of Social Psychology* (pp. 348–388). John Wiley & Sons.

Bohner, G., & Dickel, N. (2011). Attitudes and Attitude Change. *Annual Review of Psychology*, *62*(1), 391–417. https://doi.org/10.1146/annurev.psych.121208.131609

Bradburn, N. M., Sudman, S., & Wansink, B. (2004). The Social Context of Question Asking. In *Asking Questions* (pp. 3–34). John Wiley & Sons.

Breckler, S. J. (1984). Empirical validation of affect, behavior, and cognition as distinct components of attitude. *Journal of Personality and Social Psychology*. https://doi.org/10.1037/0022-3514.47.6.1191

Carnevale, A. P., Smith, N., & Melton, M. (2011). *STEM*. https://doi.org/1

Chiu, T., & Ho, C. (2013). The Study of Emotion Responses when Applying Scents to Products. *IASDR 2013 Congress*, 2913–2924.

Cohen, L., Manion, L., & Morrison, K. (2018). Questionnaires. In *Research Methods in Education* (8th ed., pp. 471–505). Routledge.

Colomeischi, A. A., & Colomeischi, T. (2015). The Students 'Emotional Life and Their Attitude toward Mathematics Learning. *Procedia - Social and Behavioral Sciences*, *180*(November 2014), 744–750. https://doi.org/10.1016/j.sbspro.2015.02.192

Crano, W. D., & Prislin, R. (2006). Attitudes and Persuasion. *Annual Review of Psychology*, *57*(1), 345–374. https://doi.org/10.1146/annurev.psych.57.102904.190034

Czaplinski, I., Mallet, D. G., Burrage, P., & Psaltis, S. (2015). Preparing engineering graduates for the knowledge economy through blended delivery of mathematics. *School of Mathematical Sciences; Science & Engineering Faculty*, *July*, 6–9.

de Vries, M. J. (2016). Teaching about Technology. In *Teaching about Technology*. https://doi.org/10.1007/978-3-319-32945-1

Desmet, P., & Hekkert, P. (2013). Framework of Product Experience. *International Journal of Design*, *1*(1), 1–11.

Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes*. Harcourt Brace Jovanovich.

Farrugia, L., & Borg, J. (2016). Design for X' Based on Foreseeing Emotional Impact of Meetings with Evolving Products. *Journal of Integrated Design and Process Science*, *20*(2). https://doi.org/10.3233/jid-2016-0017

Farrugia, L., & Borg, J. C. (2014). Towards handling worker emotions for improved product development. *Proceedings of the 10th International Workshop on Integrated Design Engineering, IDE 2014*.

George, R. (2006). A Cross-domain Analysis of Change in Students' Attitudes toward Science and Attitudes about the Utility of Science. *International Journal of Science Education*, *28*(6), 571–589. https://doi.org/10.1080/09500690500338755

Johansson, L. (2009). *Mathematics, Science and Technology Education Report*. http://www.ert.eu/sites/default/files/MST Report FINAL.pdf

Kimbell, R., & Perry, D. (2001). *Design and technology in a knowledge economy and a distinctive model of teaching and learning*. 1–20.

Kothandapani, V. (1971). Validation of feeling, belief, and intention to act as three components of attitude and their contribution to prediction of contraceptive behavior. *Journal of Personality and Social Psychology*. https://doi.org/10.1037/h0031448

Lazarus, R. S. (1999). *Stress and emotion: A new synthesis* (1st ed.). Springer Publishing Company, NY.

Lee Do, S., & Schallert, D. L. (2004). Emotions and classroom talk: Toward a model of the role of affect in students' experiences of classroom discussions. *Journal of Educational Psychology*, *96*(4), 619–634.

https://doi.org/10.1037/0022-0663.96.4.619

Pekrun, R., Frenzel, A. C., Goetz, T., & Perry, R. P. (2007). The Control-Value Theory of Achievement Emotions. An Integrative Approach to Emotions in Education. *Emotion in Education*, 13–36. https://doi.org/10.1016/B978-012372545-5/50003-4

Pekrun, R., Goetz, T., Frenzel, A. C., & Barchfeld, P. (2011). Measuring emotions in students' learning and performance - Pekrun.pdf. *Contemporary Educational Psychology*, *36*(1), 36–48.

Pekrun, R., Goetz, T., Titz, W., Perry, R. P., Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Positive Emotions in Education. In *Beyond Coping: Meeting goals, visions and challenges.* (pp. 149–174). Oxford University Press. https://doi.org/10.1093/med:psych/9780198508144.003.0008

Pooley, J. A., & O'Connor, M. M. (2000). Environmental education and attitudes: Emotions and beliefs are what is needed. *Environment and Behavior*, *32*(5), 711–723. https://doi.org/10.1177/0013916500325007

Raa, J., Coenen-van den, Bergh, R., de Klerk Wolters, F., & de Vries, M. (1988). Basic principles of school technology. *PATT-3 Conference*.

Rosenberg, M. J., & Hovland, C. I. (1960). Cognitive, affective, and behavioral components of attidudes. In *Attitude Organization and Change: An Analysis of Consistency among Attitude Components*. https://doi.org/10.2307/3319768

Salminen-Karlsson, M. (2007). Girls' Groups and Boys' Groups at a Municipal Technology Centre. *International Journal of Science Education*, *29*(8), 1019–1033. https://doi.org/10.1080/09500690600930998

Scherer, K. R. (2001). Appraisal Considered as a Process of Multilevel Sequential Checking. In *Appraisal Process in Emotion* (pp. 92–120). Oxford University Press.

Smith, S., & Smith, G. C. (2013). *The Semantic Approach and Emotional Engineering*. 4345–4354.

Soodan, V., & Pandey, A. C. (2016). Influence of emotions on consumer buying behaviour : a study on FMCG purchases in Uttarakhand , India. *Journal of Entrepreneurship , Business and Economics*, *4*(2), 163–181. www.

Tyng, C. M., Amin, H. U., Saad, M. N. M., & Malik, A. S. (2017). The influences of emotion on learning and memory. *Frontiers in Psychology*, *8*(AUG). https://doi.org/10.3389/fpsyg.2017.01454

van Aalderen-Smeets, S. I., Walma van der Molen, J. H., & Asma, L. J. F. (2012). Primary teachers' attitudes toward science: A new theoretical framework. *Science Education*, *96*(1), 158–182. https://doi.org/10.1002/sce.20467

Wright, T., Cropanzano, R., Denney, P., & Moline, G. (2002). When a happy worker is a productive worker: A preliminary examination of three models. *Canadian Journal of Behavioural Science*, *34*(3), 146–150.

Yang, J., & Diefendorff, J. M. (2009). The relations of daily counterproductive workplace behavior with emotions, situational antecedents, and personality moderators: A diary study in Hong Kong. *Personnel Psychology*, *62*(2), 259–295.

Zanna, M. P., & Rempel, J. K. (1988). Attitudes: a new look at an old concept. In D. Bar-Tal & A. W. Kruglanski (Eds.), *The Social Psychology of Knowledge*. Cambridge University Press.

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