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Motivation, Optimal Experience and Flow in First Year Computing Science

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ABSTRACT

We examine the concept of motivation from the perspective of Self Determination Theory and give a brief overview of relevant results. We also consider the optimal state known as "Flow" and give an account of its conceptualisation in the theory due to Csikszentmihalyi. After discussion of ways in which these concepts can be measured, we describe a set of preliminary studies that investigate motivation and flow in the context of a first year computing class. We analyse student responses to enquiries about perceptions of motivation and flow experiences and look at links between them. We also discuss intrinsic motivation within the subject.

Keywords

motivation; self determination theory; optimal experience; flow

1. INTRODUCTION

The factors that affect how an individual student engages with a course of study are often complex and multifaceted, dependent upon a range of cognitive, affective and social considerations [38]. However, there is good evidence that students are much more likely to persist in higher education if they are psychologically invested in the experience of learning than if not [29, 35]. This seems intuitively obvious, and providing opportunities for learning that are both academically meaningful and cognitively rewarding is a fundamental part of professional teaching activity. The concept of motivation, viewed as the aspect of intentionality that focuses on direction and reasons to accomplish a task, is understood to play a foundational role in such concepts as self-efficacy [4, 41] and self-regulation [34]. Students themselves report that enhanced learning may follow from a variety of states characterised by high levels of engagement and increased motivation, but educational psychology research is particularly strong when considering those in which motivation is, to a greater extent, generated from within the task itself and not forced by external constraints [14].

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This result is clearly important from a pedagogical perspective and has implications for the way educators develop, deliver and assess learning activities. Given that these modalities can often vary quite considerably from discipline to discipline, it is natural to try to learn more about this in the specific context of computer science education [6].

This paper draws on two main theories from educational psychology to investigate the experience of optimal states described by some students when learning aspects of computer science. Our aim is to try to situate the experience of a student who reports such a state within the broader theoretical context of those reported in other academic disciplines, and more widely in other individual or social activities. To do this, we draw on the concepts and terminology of Self Determination Theory (SDT) [13, 14, 33] to describe various levels of motivation experienced by a student when undertaking an activity. This approach proposes that the degree of motivation depends on the individual's "locus of control" [32] i.e. the extent to which that person believes that they can control the events affecting them. It is a well-established theory which evolved out of attempts to account for the effects of extrinsic rewards on intrinsic motivation, specifically the "Overjustification Effect", i.e. the observation that, somewhat counter-intuitively, such rewards do not always motivate persistence in challenging tasks, and in some cases may serve to undermine it [12].

Since motivation is a psychological construct and therefore not directly observable, factors associated with engagement such as activation, persistence and intensity, are generally taken as proxies and assumed to correlate with it. An increase in the likelihood that a person will initiate an action, greater effort to persist in the face of challenges, and more intense activity in pursuit of goals all contribute to an operational definition of motivation. Given this, the analysis provided by self determination theory suggests that increases in these observable factors are generally correlated with increased levels of intrinsic motivation, i.e. when an individual finds a task rewarding for its own sake.

One such state is that of "optimal experience" or, to use the terminology of Csikszentmihalyi [8], "Flow". This phenomenon, in which the person feels simultaneously cognitively efficient, highly-motivated, and happy" [10], has been studied by researchers for over forty years and the concept has been found to be useful in a range of subject areas, especially in sport, music and art, where there is some degree of physical activity or performance. Flow states are characterised, within the execution of a task, by a merging of action and awareness, a centering of attention, and the loss of self-consciousness. Subjects speak of an immersive experience in which the person experiences a strong feeling of control and where requirements are clear and unambiguous. Such experiences are "autotelic" in nature, i.e. rewarding in themselves, without the need for external motivation.

Within the broad field of computing, autotelic states such as flow have been studied in a range of contexts such as immersive gaming [17, 37], game-based learning [18], instructional design [5], Information Systems adoption [23] and HCI [19, 20, 3].

We believe that the concepts of flow, and autotelic behaviour in general, are illustrated in a range of CS education contexts. These range from the programmer who becomes completely absorbed in the coding exercise, to the student working on an open-ended project. The purpose of this paper is twofold. Firstly we seek to give a general and accessible account of some of the basic results associated with Self Determination Theory and Flow Theory, and secondly we report on an initial study into these concepts in the context of first year computing science students. We analyse student responses to enquiries about perceptions of flow experiences and look at links between these reports and intrinsic motivation within the subject. We also investigate links with student perceptions of confidence and self-identity.

2. BACKGROUND

From the standpoint of practical pedagogy, understanding the basis for student motivation, and its expression in course engagement, is a key task that impacts critically on most aspects of teaching and learning. In what follows, we use the perspective of Self Determination Theory to describe motivational states, while eventually focussing on Flow-states. We therefore give a brief, general account of both of these theories before looking at how these concepts are measured.

2.1 Motivation and Self Determination Theory

Early theories of motivation focused on a classification of motives in terms of needs and how these are fulfilled. So, for example, the theory proposed by Maslow [25] as well as later developments such as such as ERG theory [1] sought to describe motivation in terms of a hierarchy of needs, with the satisfaction of its lower levels (physiological, safety) being a prerequisite for engagement with the higher levels, culminating in the need for what Maslow termed self-actualisation and self-transcendence.

While these general theories have proved useful in some fields such as sociology, they generally treat motivation as a unitary concept and this does not conform to experience within an educational context. One influential psychological theory that does attempt to consider different types of motivation is Self Determination Theory [13, 14, 33]. The theory attempts to give an account of the concept of motivation from both a social and a cognitive perspective using the degree of self-determination to characterise it along a continuum from least to most self-determined. It posits a broad distinction between extrinsic and intrinsic forms: the former referring to initiation of activities in order to fulfil some external goal whereas the latter is characterised by engagement in tasks for their own sake, regardless of any external reward structure.

Deci and Ryan visualised this as a "motivation continuum" based upon increasing levels of self-determination. At the lowest end is what they term "*amotivation*", an absence of motivation characterised by a feeling of lack of control over actions and an absence of value derived from completion of tasks. This is followed by an intermediate level of extrinsic motivation, which itself can be differentiated into a number of sub-categories. At the lowest end of this intermediate scale is *external regulation*, where motivation is caused solely by external rewards and punishments. Above this is *introjection* in which individuals begin to internalise the reasons for their own behaviour and impose their own reward structures in terms of what they perceive they ought to do. *Identification* takes place when the individual identifies with the reason for behaving in a certain way and moves from normative to volitional justification. Finally, *integrated regulation* is said to occur when the extrinsic motivation is fully assimilated and accepted into the sense of self. The distinction between the first two extrinsic categories and the latter two was also stated using the terms *non-self-determined extrinsic motivation* for behaviour completely controlled by external factors and contrasted with *self-determined extrinsic motivation* which occurs when the individual engages in an activity because of a personal choice and an attribution of socially determined values to the task.

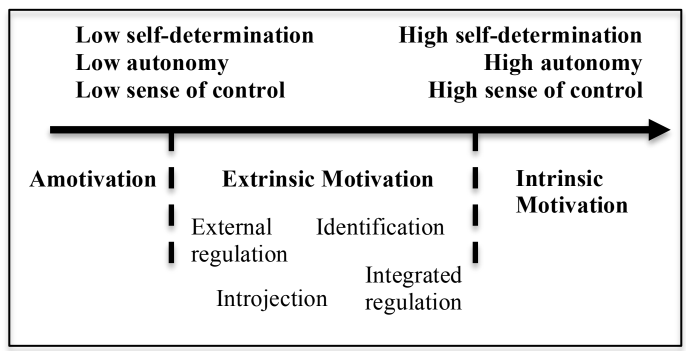

Figure 1. The Motivation Continuum (adapted from Deci & Ryan, [32])

The highest form of self-determination occurs with intrinsic motivation where participation in some task is done for its own sake, because of personal interest or the satisfaction derived from the experience. Later development within the framework of SDT investigated the effect of contextual factors on intrinsic motivation and proposed a direct correlation between high intrinsic motivation and features that promote feelings of personal autonomy and competence. Personal growth and psychological well-being are enhanced when individuals try to gain as much autonomy over their own behaviour as possible and this occurs through the development of competence in both actions and the decision-making processes that lead to them [33]. Since high-quality learning and creativity are often the result of the more self-determined form of motivation, a pedagogical priority would be to provide an environment that promotes this. Both intrinsic and the self-determined forms of extrinsic motivation have been found to be associated with positive educational outcomes such as greater engagement in learning [7], better performance [27], and greater psychological well-being [36].

The dual need for autonomy and competence is accompanied by a further motivational factor, that of the desire for relatedness. This is a contextual factor in which individuals seek to establish a psychological connection with others and is especially important in the setting of social interactions, such as those that occur in learning environments. SDT proposes that people have an innate tendency to internalise new knowledge and the practices that are acquired through socialisation, and that satisfaction of the need for relatedness facilitates this process of internalisation. In particular, external motivators derived from the values and practices of other people with whom an individual feels (or desires to feel) some kind of connection, are accepted as his or her own and transformed into intrinsic motives. This would, for example, be important in an educational context where academic maturation is seen as a process by which the learner is inducted into a community of practice, taking on the norms and values of that community. In the context of secondary school, such relatedness has been shown to be associated with student perceptions of value and respect from teachers and parents, and this understanding fosters intrinsic motivation [21]. SDT therefore maintains that, when students' basic psychological needs for autonomy, competence, and relatedness are supported in the classroom, they are more likely to internalize their motivation to learn and to be more autonomously engaged in their studies.

Later elaboration of the theory [40] proposed a multidimensional picture of motivation and suggested that different motivational impulses needed to be incorporated in any comprehensive account of the concept. In sport science research, for example, more autonomous motivational factors such as self-determined extrinsic motivation have been linked to enhanced performance and more effective coping strategies in the face of set-backs [2], greater levels of persistence and higher levels of time investment in activities [30].

2.2 The Concept of Flow

While Deci, Ryan and their co-workers were investigating these concepts of motivation in the context of Self Determination Theory, other aspects of intrinsic motivation were being developed by other researchers. One such motivational theory was that elaborated by Csikszentmihalyi based on the concept of "*Flow*". Csikszentmihalyi [8] defined flow as "the holistic sensation that people feel when they act with total involvement". Following interviews with individuals pursuing a variety of different activities - artists, dancers, chess players, rock-climbers, surgeons – Csikszentmihalyi noticed common elements in their description of feelings of optimal performance. In particular, expressions such as "being in the midst of flow" or "flowing from one moment to the next" were often used to describe such experiences

Flow states are states of heightened experience in the sense that the person involved in the activity feels "simultaneously cognitively efficient, motivated, and happy" [9, 28]. Moreover, Csikszentmihalyi and others found that these states correlated with enhanced performance in a variety of creative and sporting activities, as well as learning [31, 16]. The conditions of flow include a sense that one is engaging in challenges at a level which is appropriate to one's capacities, having clear, proximal goals with immediate, accessible feedback about progress that is being made. The enjoyable nature of flow promotes learning and engagement with more complicated activities since, to maintain the state, the subject of the experience has to maintain the balance between challenge and skills, resulting in a synchronized increase in task difficulty as proficiency develops. It was this unfolding "virtuous circle" of self-actualisation, in which an individual continually seeks out new tasks by setting, and ultimately surpassing, increasingly challenging problems, that Csikszentmihalyi saw as the key not only to a rewarding and productive life for the individual [11] but also for the flourishing of whole communities and cultures [26].

Csikszentmihalyi early work on flow describes a number of elements that characterise the state. The first is a "merging of action and awareness" in which a person is aware of the actions being performed but not the state of awareness itself. There is a focusing or centering of attention on the specific details of the problem at hand and a loss of self-consciousness so that individual considerations become irrelevant to the task. This is accompanied by feeling of control or mastery over the performance of the task together with clear, unambiguous knowledge of the course of action, clarified by immediate and plain feedback. Objectives are perceived as logically connected with a clear order of operation and reaction to subtasks is automatic. Finally, the state has an "autotelic" nature, that is, there is no need for external goals or rewards as the experience of participation is its own reward.

In subsequent elaboration of the theory, Csikszentmihalyi [11] and others also suggested that further characteristics of flow included a sense of "the distortion of temporal experience of time", i.e. that time seemed to go faster when the individual engaged in the activity in the flow-like state. In addition he looked at precursors or conditions that are required to exist before a flow-like state develops. The most important of these is that a person should have a feeling of control over the process with a balance between the challenge involved and the skills required to complete a task.

The challenge-skill requirement has led a number of researchers to try to develop a model of flow based on these components. One developed by Csikszentmihalyi and LeFevre [9] is the Quadrant model.

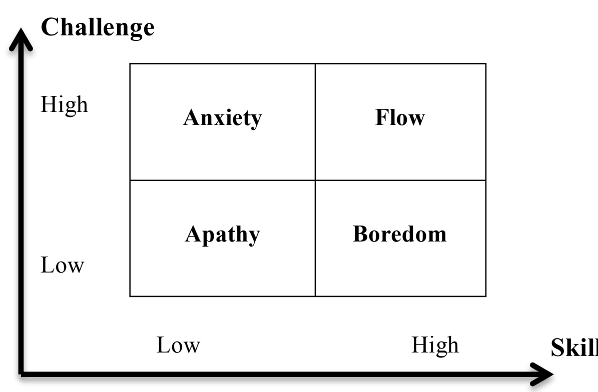

Figure 2. The quadrant model of the flow state (Adapted from Csikszentmihalyi & LeFevre 1989, [9])

An expanded version, the Octal, or Experience Fluctuation model, was developed in Massimini et al. [26] which kept the two-component axes of the model but included a finer classification of sectors in the diagram. It retained the apathy-flow characterisation of the low-to-high diagonal but included more nuanced states surrounding these corresponding to medium-level values of challenge and skill, e.g. "control" (high skill/medium challenge) and "worry" (low skill/medium challenge).

Whatever the precise details of the particular model, there seems to be agreement in the literature that flow is associated with high skill/high challenge situations and that the cognitive and affective reward experienced by the individual is such that they are more likely to engage in the activity again. This has implications for learning akin to the previous discussion about optimal states in the context of intrinsic motivation.

3. METHOD

We wished to investigate concepts such as intrinsic motivation and flow in the context of first year computing students. The question we wished to answer was whether the states described by students were similar to those found elsewhere in the literature and whether they exhibited the same structure as those found in flow questionnaires in other situations. Previous discussion with the individual members of the student cohort had attested to a general feeling that many of them had had prior experience of optimal states, which they themselves interpreted as flow, although not necessarily in a computing education context. Many of these had been in the more reported setting of computer gaming, music or other artistic performance, or in sport. We wished to investigate whether they perceived being in such states in the context of their university computing education. In this initial study, we were not trying to check the veracity of the claims themselves, but simply trying to compare the characteristics of the states reported with those described elsewhere in the literature. Consequently, although we collected data from a general population of first year computing students, the data analysis was restricted to those students who reported that they did have some flow-like experience. This reduced the sample size somewhat but we still feel the quantitative results obtained are useful for this initial study especially when taken in conjunction with more qualitative text-based data that was subsequently sought from individual students.

3.1 The Participants

Our study used data obtained from a group of forty first-year undergraduate students in Robert Gordon University. The students in the investigation were aged between 17 and 30 with the majority having entered university directly from secondary school. They were registered on four degrees within the School: the largest group was studying Computer Science, with the remainder studying Business Information Technology, Graphics and Animation and Digital Media degrees. The first three of these courses undertook identical course units in the first year while the Digital Media students took the same subjects but with a programming course unit more tailored to their specific subject. The students had completed the first semester course when the questionnaires were distributed. Results from 64 students were collected, of which 40 completed the two questionnaires and reported some experience of a state similar to flow.

3.2 The Questionnaires

The students were asked to complete two questionnaires. The first was a 24-item motivation survey based on a subject-specific version of the Sports Motivation Scale-6 (SMS-6) [24], which was itself an adaptation of the academic motivation scale (AMS) [39]. It was decided to use the SMS-6 rather than the original AMS because the latter did not specifically address the most autonomous form of extrinsic motivation: integrated regulation. Since our main interests were precisely in the more self-determined forms of motivation, this was not appropriate for us. In addition, SMS-6 had previously reported high levels of convergent validity with measures of flow. The use of the SMS-6 outside its original domain of application (sports science) required some slight alteration of the text to refer to computing rather than sporting activity but this was fairly straightforward as the original had been developed from the more general AMS and many of the questions reflected this, e.g. in most case it was possible to substitute "computing activity" for "sporting activity".

The questionnaire itself comprised twenty-four statements and was constructed to track 6 factors associated with types of motivation in self determination theory, namely amotivation, the four subcomponents of extrinsic motivation, and intrinsic motivation. The data collected consisted of responses to the question "Why are you studying computing?". These responses comprised a set of statements, agreement with which was rated on a seven-point Likert scale from 1 ("Does not correspond at all") to 7 ("Corresponds exactly"). The statements included in the questionnaire were divided into groups corresponding to the motivational typology described by SDT. So, for example, those corresponding to amotivation (lack of perceived control) include "*I have the impression of being incapable of succeeding in this subject*", and "*I don't seem to be enjoying computing as much as I did*" while those for identified regulation (where the person starts to internalise the externally motivated reasons for doing something) include "*Because it is a good way for me to learn lots of things that would be useful to me in other areas of my life*" and "*Because it is one of the best ways to maintain good relationships with my friends*". Also, intrinsic motivation is addressed with statements such as "*For the excitement I feel when I am really involved in the activity*" and "*For the satisfaction I experience when perfecting my abilities*".

The second questionnaire was the Flow-State Scale (FSS) [22]. This is a well-established survey instrument that attempts to measure flow in the context of sport or physical exercise. As with the SMS-6, this FSS required some textual change in order to refer to a computing context rather than a sporting one but this was straightforward to accomplish. The questionnaire is made up of 36 items divided into 9 components that track elements described by flow research. These consist of autotelic experience, clarity of goals, the balance between challenge and skill, concentration on task, feeling of control, unambiguous feedback, the merging of action and awareness, the loss of self-consciousness and the transformation of time. Students were asked to recall one specific instance that occurred while participating in the programming module that they believed constituted an optimal experience in the sense described previously. Response was then given to the items in the flow questionnaire using a 5-point Likert scale where 1 indicated "Strongly disagree" and 5 indicated "Strongly agree". For example, one statement tracking autotelic experience was "*the experience was really rewarding*", one for challenge-skill balance was "*I was challenged but believed my skills would allow me to meet the challenge*", while an example of a statement tracking concentration on task was "*My attention was focussed entirely on what I was doing*".

4. RESULTS AND DISCUSSION

Factor analysis of the questionnaires yielded results that were generally in line with those reported in other research. For the Motivation questionnaire, both the scree plot of the principal components and Kaiser's criterion (eigenvalue > 1) indicate a 6-factor model in agreement with the claims for SMS-6. Examination of the model structure with 5 and 7 factors did not appear to facilitate greater identification of the factors themselves.

Internal consistency of the responses to the components within the questionnaire was acceptable with Cronbach alpha scores in the range 0.68 – 0.87. Given the rotated factor loadings and the questionnaire rubric, attempts to identify the factors suggested strong evidence for the components of Introjection and Amotivation. There was less definitive (although still reasonable) evidence for Integrated Regulation and Intrinsic Motivation and some for External Regulation. The last factor was difficult to identify but appears to be a mixture of Identified Regulation with Integrated Regulation, and therefore would represent the initial stages of self-determined extrinsic regulation according to the classifications used in self determination theory.

Turning to the Flow State Scale questionnaire, we again saw broad agreement with results from other fields, although there is more variation with this questionnaire. Factor analysis yields a scree plot of the principal components that has one large eigenvalue with a number of smaller ones. Kaiser's criterion gives 9 factors although visual inspection of the plot did not reveal any significant points of inflection beyond the first eigenvalue. This suggests that identification of the subsequent factors is difficult and this is indeed what is found.

The first factor is a mixture of components associated with the "Challenge-Skill Balance" and "Merging of Action and Awareness". The second factor appears to be associated with "Clarity of Goals" and "Unambiguous Feedback" while the third factor is "Concentration on the Task at Hand". The fourth factor has a mixture of responses about "Transformation of Time" and "Loss of Self-Consciousness". The identity of factors after this becomes difficult as the loadings become smaller and no set of value tends to dominate. It should be noted however that a similar factor analysis carried out with 8 factors also gave rise to identification of these factor groupings although not in the same order. It is therefore reasonable to infer that the states described by students could be characterised, at least in a first approximation, by categories such as the balance between challenge and skills and a merging of action and awareness, clear objectives provided by unambiguous feedback they were receiving from the task, a high degree of concentration on the narrow remit of the task in hand, and some kind of absorption factor associated with not being conscious that time was passing more quickly.

While not reproducing the full set of factors associated with the Flow-State Scale, the results do provide some insight into the experiences reported by students. Furthermore, although, due to space limitations, we do not report here on the information gained from the more qualitative data obtained from student, this tends to corroborate the perception of flow states in terms of the variables described above.

The validity of the results reported here can of course be challenged on a number of grounds. The sample size (N = 40) is small. Nevertheless, the results are broadly comparable, at least qualitatively, with those found in in more extensive studies on the subject in areas such as sports science. It is also recognised that this initial study says nothing about those students who claim not to have such optimal experiences at any point in their educational journey through computing.

5. CONCLUSION

While the results discussed above are only an initial foray into the study of optimal experience in computer science education, we do believe that the subject is deserving of further, more systematic investigation. The link between engagement and intrinsic types of motivation appears to be both intuitively reasonable and fairly well-documented in the educational psychology research literature. Furthermore students do appear to report these states in other areas such as leisure activities, performance arts and sport. Of course, the fact that a student reports some degree of absorption and loss of self-consciousness in one particular activity, e.g. playing an immersive video game, does not necessarily imply that this state is the same as one that occurs in a learning context, say, a particularly engaging coding exercise. Nor, by itself, does it signify the existence of an optimal state such as flow. It may also be that, even if such states do exist in a non-educational situation, their benefits are not transferable to a pedagogical context.

Nevertheless, even if they only serve to motivate students to engage with an activity in order to recapture affective aspects of the optimal experience, this would enhance engagement, and so there may well be merit in further investigation. The idea that a significant aim of education is to promote intrinsic, or at least self-determined extrinsic motivation for activities is an attractive one. States of intrinsic motivation, such as flow, purport to set up a virtuous circle in which students themselves desire to perform well in challenging situations that push the limits of their skills, which then prompts them to develop greater expertise. This approach is paradigmatic in post-university education and is something that finds support in the discussion of cognitive skills necessary for lifelong learning. Nevertheless, while computer science education is necessarily concerned with the development of the technical skills and professional competencies that allow students to gain employment in the computing industry, it is surely also about allowing students to develop insights into the aesthetic and, perhaps, transcendental nature of the subject. We would wish to facilitate and indeed, where genuine, validate the experiences that some students have while studying the subject and it does appear that they are often associated with cognitive states such as flow. Such considerations also appear to be relevant to questions concerning student identity. Students who report flow-like experiences are more likely to identify as a member of the practising community and some of the questions on the Flow-State Scale questionnaire are directed to the investigation of the self-attribution of subject- or discipline-based identity, e.g. "I do this because I am a computer scientist" as well as that of learning identity in the sense of Dweck's Self-theory [15]. Trying to understand the nature and implications of identity in learning is an important issue and we therefore believe that the concept outlined in this paper will be of use in the future, and that further work in this area is warranted.

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