Applying Quantified Self Approaches to Support Reflective Learning

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ABSTRACT

This paper presents a framework for technical support of reflective learning. This is derived from a unification of theories on reflective learning with a conceptual framework of Quantified Self tools. Reflective learning means returning to and evaluating past work performances and personal experiences in order to promote continuous learning and improve future experiences. However, theories of reflective learning are currently of very theoretic nature and do not sufficiently consider technical support. Quantified Self (QS) is a collaboration of users and tool makers who share an interest in self-knowledge through self-tracking. This interest results in a variety of tools to collect personally relevant information with the purpose of gaining self-knowledge about one's behaviors, habits and thoughts. Hence, QS approaches offer a rich source of data for learning analytics that has not been available for learning processes before. However, these are rather experimental approaches and currently there is no unifying framework that clusters and connects these many emergent tools with the goals and benefits of their use. This paper brings these two strands into one unified framework that shows how QS approaches can support reflective learning processes on the one hand and how reflective learning can inform the design of new QS tools for informal learning purposes on the other hand.

Categories and Subject Descriptors

J.1 [**Administrative Data Processing**]: Education; K.3.1 [**Computer Uses in Education**]: Collaborative learning, Computer-assisted instruction (CAI), Computer-managed instruction (CMI), Distance learning

General Terms

Theory

Keywords

Reflective learning, Quantified Self, Learning Analytics, Framework, Mobile applications

1. INTRODUCTION

Reflection is becoming of relevance in the learning community and therefore reflective learning is being investigated in both educational and work settings. According to Boud et al. [1], learning by reflection (or *reflective learning*) offers the chance of learning by returning to and evaluating past work and personal experiences in order to improve future experiences and promote continuous learning. Several approaches show initiatives to support reflective learning through technology in different settings [21, 9, 7], but we lack an unifying framework that describes the role of technology in the reflective process.

On the pragmatic side, a new kind of lifelogging approaches are becoming increasingly popular that are pursued by a community known as Quantified Self (QS) [22]. Quantified Self is a collaboration of users and tool makers who share an interest in self-knowledge through self-tracking with the principle "self-knowledge through numbers". This interest results in a variety of tools to collect personally relevant information for self-reflection and self-monitoring, with the purpose of gaining knowledge about one's own behaviors, habits and thoughts.

This way, whereas Quantified Self approaches are pragmatic, having as main driver the experimentation; reflective learning is driven by theories that are evolving since the beginning of the 19th century. In an approach to join these two streams, this paper presents a framework that shows how QS approaches can support the process of learning by reflection and informs the design of new QS tools for informal learning purposes. The starting point for the design of the framework was the survey of several QS tools, which allowed to analyze the characteristics these tools may have in common. Moreover, the continuous advances in technology can facilitate this process of data gathering and therefore the quality and features of the tools. Sensor technologies are being improved, mobile technologies and devices are more widespread and Internet provides ubiquitous access to information.

In the following, we describe the theoretical and pragmatic background of reflective learning and Quantified Self in Section 2, before we present our framework to apply QS approaches in order to support reflective learning (Section 3). Finally, we conclude this paper with its discussion in Section 4.

2. BACKGROUND OF THE FRAMEWORK

This section introduces the underlying concepts of reflective learning theory and Quantified Self.

2.1 Theoretical Background

Decades of research in reflective learning have highlighted different aspects of reflective learning, leading to multiple theories [4, 8, 1, 18]. Hence, it is difficult to define a shared understanding about reflection. We were looking for a theory that provides insights into the cognitive processes and can be a basis for the integration of technology into the reflection process. We chose the model introduced by Boud et al. [1] as theory behind our framework because it considers the complete cognitive process, including affective aspects, but does not define the concrete activities around this process or a specific domain.

In the model by Boud et al., reflective learning refers to "those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciations" [1]. Therefore, the reflective process is based on the experiences of the learner, i.e. "the total response of a person to a situation, including behavior, ideas and feelings". The reflection process consists of three stages, in which the learner re-evaluates past experiences by attending to its various aspects, and thereby producing outcomes, which can be cognitive, affective or behavioral. The reflection process and its context, experiences and outcomes, are depicted in Figure 1. **VR: Add sth to trigger**

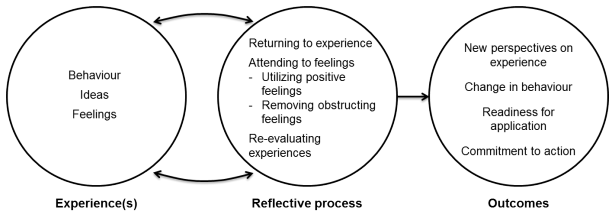

Figure 1: The reflection process in context [1].

2.2 Pragmatical Background

On the pragmatic side, Quantified Self (QS) [22] has emerged as a collaboration of users and developers who share an interest in self-knowledge through self-tracking. The principle that shows their philosophy is "self-knowledge through numbers". The lifelogging experiments that they perform and the tools they use have the intention of gaining knowledge about their own behaviors, habits and thoughts by collecting relevant information related to them. The starting point of the QS initiative are not scientific theories, but it is based on empirical self-experimentation. Apart from Quantified Self, all these approaches and tools can be also found under a variety of names including personal informatics, living by numbers, self-surveillance, self-tracking and personal analytics [10].

Since the QS community was founded, we have seen a wide variety of approaches where people track, e.g., more than 40 different categories of information about the own health, the power usage of a thatched cottage or Vitamin D consumption [2]. Besides, plenty of tools are already available, which facilitate the tracking of different aspects of our lives. Some of these tools are web-based applications (e.g. Dopplr [6], daytum [3], moodscope [13]), others are devices provided with physiological or environmental sensors (e.g. MIO [11], SenseCam [19], DirectLife [17]) and yet others consist of mobile applications (e.g. Sleep Cycle [20], oneLog [16], My Tracks [15]).

3. A FRAMEWORK TO APPLY QS APPROACHES TO SUPPORT REFLECTIVE LEARNING

In the previous section, reflective learning and Quantified Self were introduced and defined for the purpose of this paper. In the following we now present a framework that combines these research strands into a model for the technical support for reflective learning; centered around the model of Boud et al [1].

In our framework, three main support dimensions are identified, namely: tracking cues, triggering and, recalling and revisiting experiences (see Fig. 2):

(a) Tracking cues: capturing and keeping track of certain kinds of data as basis for the whole reflective learning process.

(b) Triggering: fostering the initiation of reflective processes in the learner, based on the gathered data and the analysis performed on it.

(c) Recalling and revisiting experiences: supporting the learner in recalling and revisiting through the enrichment and presentation of data in order to make sense of past experiences.

Figure 2 shows these three dimensions in relation to the reflective learning model of Boud et al. presented in the previous section. Firstly, *tracking cues* is directly related to tracking of behavior, ideas and feelings, which are the source of the reflective process on the one hand, and on the other hand related to the measurement of outcomes (e.g. new perspectives or change in behavior), which are continuously integrated with the original cues in order to feed future iterative reflection processes. Secondly, *triggering* is related to the start of the reflective process. Finally, the *recalling and revisiting experiences* enrich the process of returning to and evaluating experiences, as well as that of attending to feelings.

In the following we further differentiate the support dimension based on how these can be instantiated by Quantified Self tools.

3.1 Tracking Cues

Tracking means the observation of a person and his/her context in order to aid the reflective process. Tracking strives to quantify (aspects of) a person's life in order to enable some objectivity in understanding it. Tracking facilitates reflective learning by collecting data on experiences and outcomes that can then be used as objective basis in reflection and triggering. We further characterize tracking by the means that are used, the object that is tracked, and the goal that is being strived for.

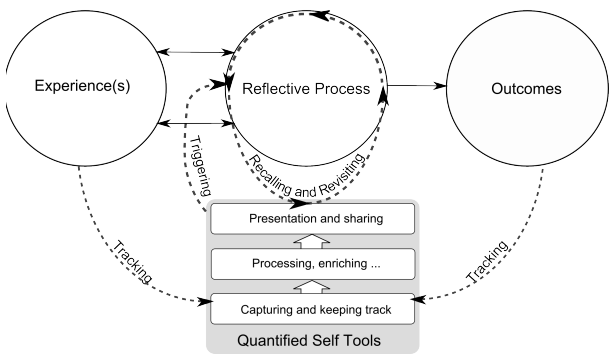

Figure 2: Role of the three QS potentials in the process of reflective learning.

3.1.1 Tracking means

Two main ways for tracking exist: self reporting through often specialized software and hardware sensors that directly track behavior.

Software Sensors

Software sensors are applications (desktop-based, web-based or mobile-based) that aid the user in capturing experiences. Software sensors are particularly important for experiences that cannot (currently) be directly measured (such as feelings, ideas) and are often much simpler, more flexible and cheaper to realize than hardware sensors. Software sensors are currently used in a broad variety of QS applications.

Hardware Sensors

Hardware sensors are devices that automatically capture data that can be used to deduce experiences or collect contextual information. Common categories of sensors are: environmental sensors (e.g., light sensors, thermometers or microphone) and physiological sensors (accelerometers, heart rate sensors, sphygmomanometers, etc.).

3.1.2 Tracked Aspects

Of crucial importance to Quantified Self applications is the selection of data about experiences and outcomes that is being tracked; what is tracked is likely to have a large effect on user acceptance and efficiency for reflective learning. The tracked aspects found in Quantified Self applications can be classified in the following way:

Emotional aspects

Emotional aspects such as mood, stress, interest, anxiety, etc.

Private and work data

Data from work processes and our lives such as photographies, the browser's history, digital documents, music, or use of a particular software etc.

Physiological data

These are physical indicators and biological signals that describe a person's state of health. The main approaches comprise the measurement of physical activity (for applications focusing on sport) and factors indicating health and sickness (e.g. glucose level).

General activity

Data about a users' general activity such as the number of of cigarettes, cups of coffee, hours spent in a certain activity or number of times that something is done.

3.1.3 Purposes

Another important classification dimension is that of the purpose of a Quantified Self application; the goal which the user tries to achieve by using this application. This purpose drives and guides which measures are tracked and which means are appropriate.

3.2 Triggering

Within the reflective learning process, triggers are responsible for starting the actual reflection process. The role of triggers is to raise awareness and detect discrepancy. We differentiate between *active* and *passive* triggering.

3.2.1 Active

Active triggering consists of the tool sending a notification or catching the attention of the user explicitly. In order to support active triggering, an application must perform data analysis to detect experiences that are suitable for initiating reflection. Such a situation may be a mismatch between a user's goals and current level, comparison to a global threshold or other persons or a deviation from personal patterns.

3.2.2 Passive

A system supporting only passive triggering does not identify experiences suitable for fostering reflection or it would not actively contact the user. This kind of system only displays the collected data in a suitable way. It relies on the user to be triggered by somethings outside of the system or on the user regularly visiting the site and then detecting something that starts a reflection process.

3.3 Recalling and Revisiting Experiences

Different aspects affect the recalling and revisiting of past experiences, when analyzing the benefits that QS approaches could offer. Enrichment and presentation of the data may facilitate the revisiting of the data to analyze past experiences and reflect about them, and therefore enhance the learning process of the user.

So support of Quantified Self applications can exist along multiple dimensions: Contextualization, Data Fusion, Data Analysis, and Visualization.

3.3.1 Contextualizing

The data being tracked can be enriched with other context data. This contextualization of the data with other sources of information may be performed by the same tool or result from the interaction between tools (e.g. two mobile applications or a sensor with a desktop application).

Adapting the context definition from [5] we define context within this framework as: Context is any information that can be used to characterize the situation of a tracked entity and that can aid the reflection process.

Social context

Data can be augmented with information about the social context of the user. This can be a comparison to Facebook friends or a comparison to all users. This helps to compare own performance/measures with the others and provides additional data to others in expectation to retrieve more data

in exchange and ultimately see one's own experiences in relation to other's. An aggregation of data over multiple users may provide new perspectives on experiences and offer new abstraction levels. Such an aggregation can be useful for individual reflection but also at a collaborative level, e.g. reviewing team performance over one month [12].

Spacial context

The location in terms of city, street or even the room. As context this data can aid reflection by helping the user to understand the relation between place and his behavior - such as undestanding the effects of high altitude on his or her heart rate, the calming effect of visits to specific places or the identification of the places where most time is lost in traffic.

Historical context

Historical data is a further type of context data that can aid in the reflection process. Comparing current values to historic ones allows to see upward or downward trends or to identify deviations from a historic norm that may indicate a problem. Historic data may also help to identify the difference between periodic fluctuations (such as variations in weight or fitness according to the seasons) and other deviations from the norm that may indicate progress or a problem.

Item Metadata

Any metadata available about the things a user interacts with – such as the information that a particular website a users is accessing is not work related but rather distracting, or the information that a food someone ate contains a large amount of sugar.

Context from other datasets

In addition there are numerous datasets (e.g. weather or work schedule) that might can also be used in contextualizing.

3.3.2 Data fusion: Objective, self, peer and group assesment

One important aid to the reflection process can be the fusioning and comparison of objective (i.e. measured by sensors), self (i.e. self reported data from the user), peer and group assesment (reported data from others about a user). There may be differences and discrepancies between these views that can foster reflection, can help to bridge the gap from subjective to objective experiences and in this way yield new insights and lead to learning. This relates to stage two of the reflection process – attending to feelings. Negative impressions can be discharged by comparing the individual perspective to objective measurements. Aggregation of subjective articulations over time or over different users can result in a more objective view (see also [14]).

3.3.3 Data Analysis: aggregation, averages, etc.

Different forms of data processing help to present the user useful measurements (e.g. number of cups of tea per day/week, average mood of my colleagues, etc.). In [12] we suggested formal, graphic and mathematic aggregation, depending on the data and purpose of the aggregation. For instance, aggregation in tag clouds as example of formal aggregation may need large amounts of data to become valuable but can be applied to semi or unstructured data like texts. Further, it might be desirable to hide the source of the underlying data through aggregation and in this way to create anonymity and privacy.

3.3.4 Visualization

It is necessary to choose attractive and intuitive presentation and visualization forms for the users that, at the same time, foster the analysis of the data for reflective learning purposes and being otherwise one of the major barriers (see [10]).

4. DISCUSSION AND CONCLUSION

This paper presented a framework for the application of Quantified Self applications to support reflective learning. In addition to ordering this strand of research, this framework is geared towards beeing used to understand the design space this kind of applications as well as understanding which parts haven't been addressed by research. In the following we want to introduce some of the issues that were identified when reviewing existing research into Quantified Self applications within this framework.

Assuming that Quantified Self tools can be shown to help people achieve their desired outcomes, there is also a luck of understanding on how to identify the situations where they are likely to work, which are the right measures to track and finally how to spread the user beyond the current relatively narrow user base.

Currently there is also relatively little work on contextualizing the data to improve the reflective process. Different QS applications are islands where data from one application and sensor cannot be used to understand that of another people. The use of external data sets (such as historic weather data in fitness applications) is even less common.

Overall the proposed combination of reflective learning and Quantified Self applications in the proposed framework concretizes the vision of learning analytics for a particular model of learning and class of support tools. In doing so it allows to identify promising venues for future research. It also shows the way how the notion of learning analytics can be applied beyond classroom settings in daily life to support all kinds of learning and self improvement.

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