A Critical Reflection on the Position of Mobile Device Based Tools to Assist in the Professional Evaluation and Assessment of Observable Aspects of Learning or (Game) Playing

A Critical Reflection on the Potential of Mobile Device Based Tools to Assist in the Professional Evaluation and Assessment of Observable Aspects of Learning or (Game) Playing

Hanno Hildmann[1] and Jule Hildmann[2]
[1]University of the West of Scotland, Paisley, UK
[2]Ludwig-Maximilians-Universität, Munich, Germany
hanno@cypherpunx.org, jule.hildmann@gmx.de

Abstract: In the past few years a large amount of work has been done in the field of games based learning, mainly with respect to computer based applications. However there have been other, much older and traditional areas of (or related to) games based learning that have also received drastically increased attention from the research community in recent years. The public interest in matters concerning paedagogics has literally exploded, an observation reflected in the coverage by the mainstream media. In previous work the authors have reported on practical hands on studies from the classroom (J. Hildmann) or proposed a formalism designed to represent unambiguous descriptions of observable aspects of learning or (game) playing (H. Hildmann). In this paper aforementioned formal approach is linked to innovative approaches for behavioural evaluation of children and experiential paedagogics, in specific to initiative games. The background of the authors allows the merger of the theoretical contribution from the field of computing with the practical considerations, criticism and requirements of an expert "in the field", i.e. one of those professions that will ultimately be using these new approaches as well as judging and evaluating them.

Keywords: Adventure/initiative games, experiential education, behavioural psychology, social skills, mobile devices, computer based assessment and evaluation

1. Introduction

The term experiential education refers to a modern approach in education which deviates from the old fashioned paradigm of a hierarchical one-way delivery of content. It aims to combine multi sensor stimuli with practical learning as well as making use of emotional incentives and learning strategies in order to facilitate development. It focuses for a large part on making the participants aware of their already existing competences and abilities before working to enhance them. There is a large amount of literature and research demonstrating the positive outcome of experiential education programmes mainly in respect to social skills, self-esteem and problem solving (cf. Rehm, 1999). Although these programmes are originally, and even now primarily, set in an outdoor and/or adventure context, in the past years a field or nature-independent activities have emerged and is by now well established, e.g. as *City Bound* (Deubzer & Feige, 2004) or initiative games that can also be practiced indoors. They always pose a practical challenge that needs to be mastered with creativity, problem solving skills and physical action. Usually they are designed for groups, thus also requiring and promoting cooperation, effective communication strategies and team spirit. Common examples are crossing a stream (real or imaginative), transporting an object without touching it or finding a path while blindfolded and / or forbidden to speak (Rohnke, 1989).

Just recently, this approach has also been introduced into regular school lessons in Germany to promote social skills in pupils while at the same time transporting the academic curriculum (Hildmann, in review). To achieve this, a number of working principles of experiential education were employed in conducting the lessons, such as giving the pupils as much self responsibility as possible and designing the tasks in a manner such that several approaches are possible to reach a satisfactory solution.

A qualitative experiment conducted with four classes of eighth formers over two six months periods has proven this approach to be very successful in terms of promoting social and personal competence.

2. Observable aspects of behaviour

2.1 A model for human behaviour choice

In 1985 Ajzen proposed the *Theory of Planned Behavior* (ToPB) as extension to his *Theory of Reasoned Action*. This theory stipulates that human decision-making (with respect to actions and behaviour) is guided by three conceptually different considerations and beliefs (Ajzen, 1985):

- *Behavioural beliefs*: The expectations about the likely outcome of one's actions, paired with one's subjective view on these outcomes.

- *Normative beliefs*: The opinion of others regarding the outcomes of one's actions, combined with the intention to adhere to the standards of others and to live up to the expectations of one's peers.

- *Control beliefs*: One's confidence towards all factors relevant to bringing about an outcome and the subjective belief of control over these factors.

2.2 A distinction of observable aspects

With respect to observable aspects of behaviour we continue to use the works of Ajzen as reference point, specifically the TACT (Target, Action, Context and Time) paradigm that was suggested for the design and the evaluation of questionnaires (within the context of ToPB related research). In this work, Ajzen (2002) argues that in order to define behaviour sufficiently the above mentioned four aspects have to be distinguished and identified in (introspective) statements regarding behaviour. His running example is *"walking on a treadmill in a physical fitness centre for at least 30 minutes each day in the forthcoming month"*. It is not always clear how to distinguish between the four aspects, a matter to which we will return further below. The labelling of behaviour as well as the distinction of which of the four aspects to assign to a part of a statement describing behaviour is subjective and therefore has to be decided upon by the trainer or the researcher. This opens the door for ambiguity. However, since we are not making any claims towards providing an objective way to assess behaviour this is not of much impact. We merely provide well-defined and consistent means to the assess behaviour. The classification, just like the eventual interpretation of the collected data, will remain the task of the person investigating the behaviour.

Ajzen himself points out that there is this ambiguity and that there are many possible additions to the basic TACT paradigm as proposed by him originally (e.g. *"within next month"* can include *"next Tuesday"*). The aim of the paper is to illustrate our suggested approach and as such it is bound to be rather general. The specifics of the project for which it is used will determine the extent to which a finer grained distinction is required; one of the first tasks in the design stage of a project is for the programmer and the trainer to liaise on that matter and to reach a consensus. Furthermore, complicated extensions will complicate the matter without adding value to the conceptual approach and are therefore omitted here. The scope and the intended audience of this article do not warrant a lengthy discourse on this matter.

2.3 Experiential education, initiative games

In experiential education the used games are often called *exercise* rather than *games*, because in the context of a professional training setting, playing games is often regarded not only as a children's activity but, if done by adults, as childish and is therefore met with resentment (Hildmann, 2008).

With respect to the 3 types of belief mentioned above in the section on behavioural psychology we briefly elaborate which of them is target and if then to which extent. Recall that Ajzen distinguishes 3 beliefs:

Behavioural beliefs:

Experiential education and initiative games can target these beliefs in two different ways:

a) In an exercise the player can face new, previously unknown actions and choices and thus gather experience related to the outcome of these actions as well as providing feedback on their desirability.

b) The game can be designed to place the player in the position to perform a known action that is normally performed by others and thus provide feedback on an otherwise merely observed action.

Normative beliefs:

These are strongly dependant on the scenario and probably the least commonly targeted beliefs of the three in experiential education. There are famous examples of experiments like the Stanford Prison Experiment (Haney, C., Banks, W. C. & Zimbardo, P. G, 1973) which were designed to investigate the extent to which these beliefs can be changed, often with horrific results. In the context of teaching these are normally continuously targeted by the trainer in the effort to make up for the increasing lack of

parental influence evidenced by today's youth, yet they are not as commonly found as the stated primary target of initiative games.

Control beliefs:

Though not necessarily the most important beliefs, these are the first that come to mind when talking about initiative games. The personal confidence towards being able to bring about something is boosted or even created, simply by placing a player in a position where a certain outcome has to be achieved and the (ideally successful) attempt to do so provides the feedback that might not normally be experienced in the everyday life of the player.

The observable aspects with respect to initiative games or experiential education in general (and within the scope of this paper!) are then e.g. the participation in group activities and efforts, individual actions, communication and the content of the communication, consideration of oneself and the other group members (social skills) cooperation (as a high level description) and creativity. This is a non exhaustive list and the actual observable aspects are of course dependant on the exercise.

We now introduce a formal language alike the one used in previous research. This language is designed to unambiguously describe relevant observable aspects of behaviour and learning. This is necessary when implementing evaluation tools for initiative exercises which are intended to function automatically.

3. A formalism for observable aspects of behaviour and learning in games

As described by Hildmann & Livingstone (2007), the language described in the following sections is standard classical propositional logic (PL) as introduced in van Benthem, van Ditmarsch, Ketting & Meyer-Viol (1991) (page 11-23); for advanced reading see Blackburn, deRijke & Venema (2001). It is explained here only to the extent required to understand the approach.

3.1 A formal language $\mathcal{L}^*$

We use a formal language, which we will call $\mathcal{L}^*$ (Hildmann & Livingstone, 2007). By formal language we mean a formally defined language that has both syntax (clearly defined structure) as well as a semantic (meaning). That language is, unlike most natural languages, unambiguous; a quality we require for our application in order to provide us with data which can be processed automatically.

The language $\mathcal{L}^*$ is constructed over a vocabulary. These *"words"* of the language are its smallest building blocks from all sentences are constructed; we can deconstruct any however complex sentence, and, using the semantic rules, propagate the truth values of the vocabulary upwards to determine for any sentence whether it is true or false. To make this language understandable to any non technically inclined person we make use of the fact that we can (mechanically) translate any sentence of this language into a natural language, for example into English. This gives us a language at our disposal that is both formal (and thus unambiguous) as well as intuitively understandable (Hildmann & Livingstone, 2007).

Motivation

We justify this section and the introduction of a formal language by our aim to provide the reader with a straight forward means to represent, implement and eventually assess behavioural statements, because:

- It gives us a well defined and unambiguous way to make statements regarding behaviour. Since the language is semi-natural a trainer can intuitively understand and verify the validity of statements in the context of the specific application, and, therefore, make use of our tool.
- Implementing a rigid evaluation method for any aspect expressed in the language allows the game designer or the trainer to amend certain behavioural aspects of the game or the tool without having to change the whole system.
- There are algorithms that allow us to automatically cerate new behavioural statements that are consistent with existing ones. Furthermore, application specific modules can be implemented that use artificial intelligence to suggest useful and meaningful statements to the user during the game or the project and while the program is running.

3.2 Behavioural psychology

Above we introduced the conceptual approach of TACT proposed by Ajzen (2002). In this section we will illustrate how this is incorporated into games. As a running example we will use the game "Glasgow SoxWars" (Hildmann & Boyle, 2009) designed to investigate cooperative and competitive behaviour.

We start by designing the game around the vocabulary of our formal language, which (as described in the sections above) is a collection of statements which at any given moment can be evaluated to be either true or false. What we intend to do is to construct statements regarding the player's behaviour such that:

- The four concepts *Time*, *Action*, *Context* and *Target* are unambiguously defined in each statement.
- Given a state of the game we can evaluate any such statement to either true (**T**) or false (**F**).
- Each statement is assigned a behavioural label (e.g. *cooperative*, *competitive*).

The last point is quite vague as it will be based on the opinion of the researcher alone. This however cannot be avoided; furthermore it is a problem that is present when constructing a questionnaire as well. In what follows we will use some insight into the example game to decide subjectively whether a stated behaviour should be seen as *cooperative* or *competitive*. It is important to remember that these labels are used to illustrate the approach, not as definitions of the two behaviours. In the next few sections we will express behaviour of a player, which we will call *Subject* and use the abbreviation **B** and **B'** which stand for either *cooperative* or *competitive* behaviour. Since we, as the researchers, define for any behaviour whether it equates to one of these two we can investigate at any moment whether a player is playing cooperatively or competitively. Using the complex statements further down below this allows us to investigate the behaviour of the player *in response* to the opponent's actions.

In our game the players have the option to offer their resources to other players. When doing so the price they can ask for this is fixed. This is to keep things simple. If price varied, the number of statements as well as their complexity would increase drastically. The player can choose from offering resources to: a single player, all players, all but one player, all players of lower rank and all players of higher rank.

Cooperative

- Subject offers trading with a single player **P** who is ranked lower than Subject.
- Subject offers trading with a single player who plays **B** against Subject.
- Subject offers trading with all players that are ranked lower than Subject.

Competitive

- Subject offers trading with a single player **P** who is ranked higher than Subject
- Subject offers trading with all players ranked higher than subject.
- Subject offers trading with all players but player **P** who is ranked higher than Subject.

The TACT labels are (omitting *Time* for now, see below):

Action :	Subject offers to trade resources …
Target :	… with player **P** / all players / all players but player **P**…
Context :	… of higher / lower rank than the subject.

In the above statements we have ignored the temporal aspect. We now add three operators to the game: *for n rounds*, *until* and *while*. In the following sentences, provide to illustrate the usage of these temporal operators, cooperative and competitive statements like the ones given above are abbreviated **A** and **B**:

Simple temporal statements

- Subject plays **A** for n rounds.

Until statements

- Subject plays **B** / **A** until player **P** plays **B'** / **A'** against Subject.
- Subject plays **B** / **A** until all other player plays **B'** / **A'** against Subject.

- Subject plays **B** / **A** until some other player plays **B'** / **A'** against Subject.

While statements

- Subject plays **B** / **A** while player **P** plays **B'** / **A'** against Subject.
- Subject plays **B** / **A** while n other player plays **B'** / **A'** against Subject.
- Subject plays **B** / **A** while at least n other players play **B'** / **A'** against Subject.
- Subject plays **B** / **A** while at most n other players play **B'** / **A'** against Subject.

Now the latter two statement types *until* and *while* are more complex than the first one. For all three types of statements we are deriving the *Target*, *Action* and *Context* from the behaviour **B** but the *until* and *while* statements allow us to use time not only in relation to the number of turns but to measure behaviour in relation to the behaviour of others as well. The Repeated Prisoners Dilemma (Binmore, 2007) is a good example of a setup where exactly this type of behaviour is investigated.

The above listed are merely examples. Many more combinations are possible. We argue that the above suffices to illustrate the complexity and expressiveness of $\mathcal{L}^*$. One can imagine that there are, in theory, statements of almost infinite length possible (restricted only by the number of temporal connectives like *until* and *while* and the upper bound of semantically different statements). Longer statements are of little use for psychological experiments or our initiative games; we are content with statements given above.

3.3 Experiential education

As above, we will assume a less than general exercise as a running example. In this case we simply assume an initiative game that makes use of mobile devices carried by each player and used for interaction and communication. This could be because the players are acting in different locations too far apart to communicate personally, because the mobile devices allow the exchange of a game currency (thereby forcing the player to effectively log all interactions that require currency exchange) or by providing information in a format that can not be communicated otherwise (e.g. providing many images as clues, which the players can share). We now consider the previously listed observable aspects of initiative game exercises, making use of the TACT paradigm wherever possible:

The participation in group activities and efforts

Assuming there is a predefined list of actions that can be performed in the exercise any activity undertaken is the ***Action*** element of that behaviour. The ***Target*** is depending on the activity but is required in order to relate one player's action to the other players'. The *Context* of the activity will define whether the player is partaking in a group effort or whether the activity is cooperative at all.

Individual actions

This is the same as above with the difference that it might not be possible to evaluate the activity right away as belonging to either a constructive group effort or a (potentially counterproductive) individual action. This can be evaluated over time in relation to other activities.

Content of communication

Clearly the *Action* here is the act of communicating; the *Target* is the player or players with which the communication is taking place. The *Context* is determined either by previous and subsequent communication and / or content that is communicated. The degree to which information is relevant is not always immediately obvious as the player might have a subjective understanding that changes this; however the relevance of transmitted information as well as the completeness are important and normally understood easily. As above this can be re-evaluated after some time.

Consideration of oneself and the other group members / Social skills

From the observation on the group members we should be able to infer at which stage in the exercise they are (or think that they are) are at any moment. Using this inferred information, we can deduce an importance of specific abilities and expertises of individual players and then monitor the extent to which

this is both understood by the other players as well as incorporated into their decisions. This is only *Context* dependant as the actions performed will themselves have *Action*- and *Target*- elements.

Cooperation

We can formally define which behaviour we are considering to be cooperative and competitive, but that will be a decision made by the trainer or researcher and will be stated in terms of the vocabulary of the formal language. We intentionally kept this part general; the previous section uses the example from (Hildmann & Boyle, 2009) which should suffice to give the reader an idea.

Creativity

This last one is going to very hard and probably impossible to formally define. This is partly due to the fact that the very understanding we have of creativity includes the notion of using previously not considered means and approaches when attempting to solve a problem. In a fully controlled setting this can easily be implemented by classifying a subset of all possible actions as *creative*, however this is almost never going to be possible in an initiative exercise scenario which is not purely conducted using the mobile device. This none withstanding there is of course the ability to closely monitor and record the actions taken by individuals and for the trainer to evaluate them separately or after the exercise is concluded.

By the above we hint that a well designed and implemented initiative exercise can very well be cast into the TACT paradigm. We will now briefly cover the functionality to evaluate and assess statements on our language by a fully automated process and then discuss the use of mobile electronic devices for experiential education and initiative games.

3.4 Automated verification mechanisms

The automatic process of evaluating sentences in the language is straight forward. Given the formally defined semantic (van Benthem, van Ditmarsch, Ketting & Meyer-Viol, 1991) we can rewrite any sentence as a conjunction of statements and negated statements. Such sentences are called the *normal form*; they can then be automatically evaluated to be either true or false on the basis of the individual truth values of the propositions which we can determine unambiguously at any stage during or after a game. The algorithms for this are standard and can be found in most textbooks on propositional logic.

4. Mobile device based evaluation and assessment tools

We conclude that with respect to the identified requirements for electronic devices in the context of this particular research, the current standard of mobile phones or laptops can surely boast a subtle inclusion of the required technologies into their design as well as a multitude of by now very user friendly interfaces. Furthermore we refer to recent work of the first author (Hildmann, Uhlemann & Livingstone, 2008 and Hildmann, Branki, Pardavila & Livingstone, 2008) where a variety of complex implementations have been reported on as being achievable as well as computationally feasible. With respect to the objective recording of social and personal skills and behaviour, the work presented in Hildmann & Boyle (2009) indicate that the results obtained are less prone to criticism from the fields of behavioural psychology and education. Nevertheless this is a matter of specific application and implementation and there is certainly yet work to be done to bridge the gap between computing sciences and these fields.

We argue that the appropriate use of mobile devices or new technologies in general can be of great benefit to educationalists of many types, as long as they are designed as supporting tools and in accordance with the requirements of the intended users. With respect to mobile devices as platform for lessons targeting behaviour or social skills and awareness, we first isolate the areas where these devices have a clear benefit they can bring to the collaboration. In the scope of this paper two aspects emerge:

Support the game scenario and enrich the environment

Mobile devices can be used to support the scenario set by the trainer. These devices have the ability to store large amounts of data, provide a controllable communication interface, provide an audio-visual interpretation of elements of the game and interact with other devices, all of which can be used very effectively to enrich the physical environment to reflect the scenario more closely. To illustrate what is meant by this, consider the use of die or event / activity cards, which can be done in much greater variety

through an electronic device. In addition, large amounts of both game relevant (to drive the game) and irrelevant (to add to the gaming experience) information can be stored and provided on the basis of certain cues (e.g. GPS determination of position or proximity detection of (specific) other players). Finally they can be used to provide hints and clues in a variety of formats (e.g. sound, image) which are much less obvious then a statement from the tutor.

Assess and evaluate actions even during the game

Every action that is performed with such a device can be recorded and stored without the knowledge of the player. Such information can be used for a post exercise evaluation but also interpreted immediately and used either as feedback to the trainer or to intervene in the normal course of the game (e.g. the absence of a player causes the game to start a side event that requires this player to be included in the group again). If properly designed it allows the trainer to initiate a game that is not fully determined in its course yet. According to the performance of the players it can be steered one way or another. This can facilitate the targeting of multiple lessons and objectives. Finally and simply, we can view any device in the game as additional eyes and ears for the trainer, allowing a closer interaction with the game as well as adding security and accountability to the exercise (calling for e.g. medical assistance as well as locating the person in need of assistance is easily supported).

5. Critical considerations and practical concerns

This article's parallel publication (Hildmann & Hildmann, 2009) lists a number of potential advantages for the use of electronic devices in general and mobile phones in particular. Before we provide a critical view we first briefly list those positive aspects here:

- Data integrity: Electronic devices allow the individual monitoring of players or students. The gathered data can then be used to create a user specific profile that is based on the observed actions and not on introspective statements (which are traditionally unreliable due to their introspective nature).

- Data authenticity: There is a variety of mechanisms to ensure the authenticity of the data, ranging from using devices that the user will not likely share, over automatic cross-checking and comparing of answers and answering behaviour to authentication mechanisms as key cards or biometric scanners.

- Data protection laws and data security: Electronic data collection allows for a variety of levels of data security that can be controlled centrally and in manners that require a number of people to give their consent for the release of data before it can be accessed. In addition the data can be analysed automatically and the results can remain undisclosed and protected by the same mechanisms.

- Unobtrusive recording devices: High-performance recording devices are already embedded in standard mobile technologies (e.g. mobile phones or laptops). Using e.g. a 6 Megapixel camera in an up to date mobile phone to record the eye movement or facial expressions is not a difficult task.

- Individual recording devices: Being able to give the recording device into the hands of the subject has the psychological effect that the subject feels more in control and less observed. The surrendering of the physical ownership over the device to the subject is the key issue here.

As stated by Hildmann, Uhlemann & Livingstone (in press), the shortcomings of serious games are not unknown to the field; one of the dominant noted drawbacks for serious games is the lack of guidelines or means to assess and evaluate the performance of the player; therefore efforts have been made to use the aforementioned formalism and mobile devices to assess the progress of the player, both during game play as well as after the game is finished. Previous / recent work has showcased the work done on a game called "Glasgow SoxWars". The approach described in this paper follows adheres to earlier work, using the formal description of player behaviour in initiative games or other educational settings.

Both authors have been active in their fields long enough to be aware of bias found in educationalists against new technologies when these are introduced in their field of practice. The approach of digital games based learning is still suffering from this bias as innovations are often immediately rejected by educational practitioners. This reluctance can be traced to a number of (valid) core problems:

- These new techniques are developed by technicians without practical experience in educational settings. Therefore, their tools work in theory but fail to engage the pupils or are loaded with negative side effects that outweigh the benefits.

- Educationalists, by nature of their trade, will tend to reject technical devices advertising to achieve pedagogic goals. Their professional training and practical experience has taught them the vital role of personal interaction, which – so far – no computer can truly replace.

- Furthermore, when it come to approaching and handling difficult or demanding situations and issues in their classroom or respective context, practitioners are far more likely to follow their experience based intuition than the instructions of a technical device.

- Children and teenagers nowadays have a far superior understanding of new technologies than most adults, which forces the latter to give up the traditional position of authority that they have held in the past; and loss of authority often results directly in loss of respect, and subsequently, sub ordinance. Thus at least is their fear. Modern educationalists know that these assumptions are faulty.

- Additionally, each device can be used and misused. And unfortunately, many youngsters are incredibly eager to tamper with new hard and software in legal as well as illegal ways.

- Finally, some of the technologies which are used of are often financially unattainable in the required numbers, hard to maintain, not sturdy enough or too difficult to protect against theft.

The authors believe that on many occasions a good idea is rejected or failing simply because it is applied too directly or without considerations for the environment in which it is supposed to perform. Any digital or electronic device and programme which is intended to aid in the instruction and/or assessment of social skills – as in the study presented above – requires the expertise of a computer scientist and many cycles of design and implementation. This has to be undertaken in close collaboration with the end user, namely trainers, social care takers and the like to ensure the required functionality, usability and applicability.

6. Conclusion and future work

We have outlined how the TACT approach can be used to extend the language (propositional logic) used to formally state behaviour within a bounded context. Due to this extension we can make statements regarding behaviour (within the well defined terms of the game or exercise) that live up to the standards suggested by experts in the field of psychology. These statements can be assembled and deconstructed in an unambiguous manner, allowing for an interface within the game to enable the social practitioner or researcher to define the behaviour of interest for the game or the experiment; as well as being evaluated and assessed automatically. Due to this we can claim that we have presented an outline of how to implement a digital device based tool for educationalists to enrich their exercises and game scenarios. We took a critical view on the applicability and usefulness of employing digital devices in education, specifically in experiential education and initiative games and identified a number of issues and problems.

The authors of this paper agree that the design and implementation of digital or electronic tools has to be undertaken in cooperation with the intended users. The technology has to be a tool and as such one that is hand carved to meet the exact needs of the experts expected to use them. The providers of these tools are not equals to the educationalists in this decision process as their competence lies in the creation of the tools, but to the specific wishes and needs of the trainers.

More research will be necessary on the practical applicability of such programmed devices. Field experiments with children and teen-agers in school-related and out of school settings – such as social clubs, trainings for troubled youth or delinquents, and others – are equally possible as an evaluation of team trainings or other experiential education programmes designed for adults. Assessment might focus on which types of activities – initiative games, orienteering, trekking tours or the like – are most prone to profit from such devices and which same or others are best feasible to be adopted for assessment of participant behaviour.

Independent of contents of a study, all research endeavours should be conducted in cooperation of both fields of expertise, educationalists doing the 'real life base work' and computer scientists capable of designing and programming electronic devices such as mobile phones or GPS-computers used in outdoor activities for orienteering. Both groups of experts would have to be willing to cooperate in such a joint venture and adapt their professional language to achieve successful communication amongst each other – thus proving themselves worthy of assessing other people's will and skill to cooperate.

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