

From smileys to Smileycoins - Using a cryptocurrency in education

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Abstract. This paper describes a cryptocurrency to reward students for their studies. The currency bears the apt name Smileycoin or SMLY and is used within the tutor-web online learning platform. In order to make the SMLY more attractive several approaches have been used, including support from companies whose services can be purchased for SMLY. The paper describes the use of the SMLY as a reward mechanism in a large undergraduate calculus course, including student adoption, student use of SMLY, coinbase use for low-income education and abuse tracking.

KEY WORDS

1. Education. 2. Cryptocurrency. 3. Rewards. 4. Low-income regions

1. Introduction

The tutor-web¹ is a freely accessible online platform for learning.² Although the system contains general educational material (slides, handouts), the main feature is a drilling subcomponent. Here a student logs in to download sets of drill items on given topics using a mobile web interface.³ The system forms an adaptive learning environment,⁴ which has been demonstrated to increase student learning,⁵ and has been used as a general vehicle for research on educational technology.⁶

Any educational system eventually needs to have a component to evaluate student performance and the tutor-web is no exception. Such an evaluation will result in a grade, which is also a reward for the student. The purpose of the study reported here is to investigate an alternative model for student rewards.

Within a classroom the typical instructor will use various carrots and sticks, e.g. reward students by acknowledging attempts at problem solving, give high grades for good performance or draw a smiley face on a good solution paper. Experiments have been conducted on the effects of paying students real money for achieving high grades, but with conflicting interpretation of the results.^{7,8} Given the current trends in technology, a natural question to ask is whether one can conduct such experiments using electronic currencies such

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as Bitcoin⁹ and what the effect will be of rewarding students using such currencies, specifically cryptocurrencies as described below.

One famous experiment with electronic currency in education is the MIT Bitcoin experiment, where all students were given \$100 worth of Bitcoin, just to investigate the result.^{10,11} The total cost of \$1 million for such an undertaking is prohibitive for most research programmes. However, it is an easy, cheap and well-established undertaking to define a new cryptocurrency. Such a currency has therefore been developed for rewards inside the tutor-web. The resulting Smileycoin is still in its infancy but initial results are reported here.

A sister project, Education in a Suitcase, EIAS, is run as a non-profit entity to support education in low-income areas. EIAS is documented in a separate paper¹² but has important links to the SMLY, reported below.

2. Cryptocurrencies

Today's cryptocurrencies are most commonly derived from Bitcoin. In such systems, virtual coins are associated with public-private cryptographic key pairs (or addresses derived from the public keys). The holder of the private key can transfer coins associated with the address to another public address. A wallet is a computer program which stores such addresses and has the ability to announce transactions from its corresponding private keys.

These transactions are stored in a ledger consisting of linked blocks forming a chain, the blockchain. In most currencies a valid block is formed by generating a provable amount of work, using a cryptographic algorithm to solve a given cryptographic puzzle. Within the Bitcoin universe, a miner who generates such a block is permitted to allocate a prespecified block reward to one or more addresses of choice and as this is the sole technique to generate new coins in the system it is also called the coinbase. This reward is sometimes called a miner's fee but an example will be given below where that concept is not a synonym.

Competition between miners is intended to ensure integrity of the system. For Bitcoin, the algorithm used is based on the SHA-256 cryptographic hash function.[§] The rise of specialised ASIC^{**} hardware to solve the work required by SHA-256 has led to a concentration of mining power to large and expensive mining pools and therefore other algorithms have emerged for new currencies. The first such alternative algorithm was Scrypt^{††} but as ASICs for Scrypt were developed, further algorithms such as Skein^{‡‡} were developed, as described below.

[§] <https://en.wikipedia.org/wiki/SHA-2>

^{**} Application specific integrated circuit: https://en.wikipedia.org/wiki/Application-specific_integrated_circuit

^{††} <https://en.wikipedia.org/wiki/Scrypt>

^{‡‡} [https://en.wikipedia.org/wiki/Skein_\(hash_function\)](https://en.wikipedia.org/wiki/Skein_(hash_function))

A new electronic currency, the Smileycoin or SMLY, was developed to provide (and test) incentives within the tutor-web. SMLY was initially Scrypt-based with several other algorithms, including Skein, added later as described below.

The first block in the SMLY blockchain was mined on 2014-11-13 14:40:29, forming the starting time of the chain. For the next few days a chain was operated while the SMLY were tested within a course at the University of Iceland. Smileycoin was subsequently opened for general mining on November 21, 2014 13:00^{§§}, at which time 7025 blocks had been generated. As the coin was not initially open to general mining, these first blocks constitute the premine.

As with any cryptocurrency, the SMLY has a number of parameter settings. During the premine the block reward was set to 24 million SMLY for the first 1000 blocks, followed by 10,000 during in-class testing and to be used onwards for the next 7 years. These first 7025 block were thus premined and corresponding SMLY were set aside for use inside the tutor-web. The exact premine is therefore 24,060,250,000 SMLY.

After the premine phase the block reward was set at 10,000 SMLY, to be halved approximately every 7 years, specifically at every 1,226,400 blocks. Taken literally, this should result in a total of 48,511,868,000 SMLY being generated over a period of approximately 98 years. Of these, 24,451,618,000 SMLY will be generated by regular mining.

Given the way halving works, roughly half the remaining total block reward (after the premine) is mined in each 7-year period. Thus miners will generate about 12.2 bn SMLY in block rewards during the first such period.

Difficulty was initially recomputed every 3600 blocks or roughly every 5 days assuming mining hashrate to be in accordance with the difficulty. Vast changes in mining hashrate led to major changes in difficulty, although they were bounded by a factor of 4. A change in difficulty computation was therefore implemented at block 97050, in August 2015, when difficulty was re-evaluated every 60 blocks instead of the earlier 3600.

SMLY decisions are made in the SMLY forum.^{***} These include any changes in the mining algorithm, such as the change in difficulty computation.

Block reward—The block reward structure was changed in summer 2017 and made mandatory from block 218,000. Instead of the block reward being used completely for a miner's fee, it was split into three parts, the miner's fee, a "dividend" payment and a donation.

^{§§} <https://www.altcoincalendar.info/coins/997-SMLY>

^{***} <https://bitcointalk.org/index.php?topic=845761.0;all>

Thus the coinbase transaction was changed from normally having a single output to having three outputs. This change followed a migration path from initially being optional through eventually being mandatory if a block is to be accepted into the blockchain.

Suggestions on the discussion forum in this context centered around one particular change where the miner's fee would be reduced by 90% to 1,000 SMLY and the remaining coinbase of 9,000 be split between “dividend” and donation payments.

The “dividend” payment was initiated to encourage holding the coin rather than selling it immediately. When a block is mined, addresses containing at least 25 million SMLY are sorted according to when their holding was last modified, i.e. the oldest unused transaction output (UTXO) of at least 25 million SMLY is found. This address receives the entire dividend payment of 4,500 SMLY for this block.

The “dividend” payment is therefore not a regular interest rate or percentage but merely a pre-specified fraction of the block reward. It is of some interest to consider the amounts involved. First, when this was designed, a total of 54 of addresses contained at least 25 million SMLY. However, the total amount officially “available” in March 2017 was approximately 25.8 bn SMLY^{†††}, but as seen above, 24.1 of that is a part of the premine, most of which is stored in cold storage^{†††}. Thus, some 1.7 bn had been mined and in addition 2.7 bn had been allocated to students. In addition some 0.6 bn had been allocated to liquidity providers, wallet developers etc so the total actually available for general use or purchase was close to 5.0 bn SMLY. The maximum number of 25 M SMLY addresses which can be made from this amount is 200. It follows that the short-term number of recipient addresses (“rich” addresses) will be in the range 54–200. From March until implementation at block 218,000 the number of rich addresses went from 54 to 103.

Consider an intermediate number of 96 holding addresses, to pick a number which rounds nicely. Block are intended to be generated one every 3 minutes or 480 every 24 hours. These holding addresses take turns in having the oldest UTXO, receiving the interest and becoming youngest. With these numbers, each would receive the interest of 4,500 SMLY 5 times daily or 22,500 SMLY/day, giving 8.2 M SMLY per year or a 32% interest rate. Naturally, doubling the number of addresses, to the maximum current potential, halves the interest rate.

Finally, the donation is a fixed portion of each block, all of which is sent to one address in a rotating list of 10 addresses. The 10 addresses are under the control of the non-profit organisation, Education in a Suitcase^{§§§} (EIAS), which oversees any spending. Formal rules have not been adopted (yet), but discussions in the SMLY forum may well result in a formal

^{†††} <https://chainz.cryptoid.info/smly/>

^{†††} A cold storage or cold wallet is a collection of (private) addresses which are stored offline.

^{§§§} <http://educationinasuitcase.com/>

approach where votes of the holding addresses can lead to certain projects being paid for from one or more of these addresses (though some addresses will certainly remain permanently for EIAS-specific projects).

The premine—Premine in a cryptocurrency context is a debated topic. In the present case, definitions of acceptable use are laid out on the SMLY home page^{****}. Naturally, rewarding students is the core purpose but SMLY can also be donated to projects likely to increase SMLY use. Development of the allocation process is summarised on the SMLY home page (after discussion in the forum). The reward schemes are described below, but the overall scheme, after an initial test phase, has been to allocate annually roughly the same amount to students as may be mined within a year. Since reward halving is to take place approximately every seventh year, some 12.2 bn SMLY are to be given as rewards to students in the first 7 years, or about 1.7 bn annually. As will be seen below, considerable tuning of rewards is needed in order to maintain this as an average total.

Alternative methods could certainly have been chosen. For example, instead of a premine the block reward could have been split from the outset, with only a portion becoming the miner's fee and (some of) the remainder going to a tutor-web owned vault.

Mining—Mining is open (after the premine), with some minimal mining power purchased or rented by the Science Institute of the University of Iceland (SCUI) and other mining is operated privately. Cryptocurrency mining is commonly undertaken through mining pools where miners “come together” to coordinate mining for various coins. These mining pools are usually set up to direct their mining power to the most profitable coin(s), where profitability is a function of difficulty, market price and the miner's fee.

The algorithms for allocating computer power in the mining pools tend to lead to erratic behaviour for “small” coins such as the SMLY. If a large mining pool finds SMLY mining attractive and turns a large amount of mining power to the SMLY, then the difficulty will go up. At some stage the mining will no longer be profitable and the pool will abandon SMLY mining. At this stage the SMLY blockchain has low associated mining power but a high difficulty and it may take a very long time to mine a block. These problems are particularly acute when using mining algorithms such as SHA-256 and Scrypt where efficient ASICs exist and this eventually led to the decision to add more mining algorithms.

Liquidity providers—The SMLY is listed on several cryptocoin exchanges where it receives a market valuation. On these markets the various cryptocurrencies are treated like stocks on a stock exchange (albeit with little formal regulation).

As with traditional stocks on stock markets, it is important that there be some liquidity, i.e. that there is continuous trade with the coin against one or more other coins. This was

**** <https://tutor-web.info/smileycoin>

implemented for SMLY on selected exchanges and markets using automatic trading bots. On a given exchange one bot will trade SMLY on several markets, in a loop: SMLY->DOGE->LTC->SMLY, i.e. sell SMLY for DOGE, sell DOGE for LTC and finally sell LTC for SMLY. Another bot running on the same exchange will do this in reverse. In the actual implementation a bot aiming to sell SMLY for DOGE will “look” at the SMLY-DOGE market and first investigate the spread. If the spread is wide then an offer to sell is made, where an ask price is placed in the middle of the spread. However, if the spread is below a predefined threshold, then a trade occurs. The volume and frequency of these trades is primarily tuned to satisfy the requirement of the exchange in question. As the two bots compete to fill any spread using ask and bid offers followed by sell and buy requests, they maintain low spread and maintain liquidity without an obvious effect on the overall price. The two bots can access more than one exchange and can therefore decide at each stage to buy or sell at the exchange with the best price. This leads to an arbitration between exchanges at no extra cost.

Providing liquidity involves actual trades and offers. Most such trades are simply between the bots so there is little cost involved in each trade. Exchanges do, however, charge a certain percentage of each transaction. Although the arbitration counters this cost, in practise the costs are always higher than “profits” from arbitration. The liquidity bots therefore need funding, which is provided from the premine or coins generated from organised (SCUI) mining.

Mining algorithms—The initial use of the Scrypt algorithm was difficult from the start, since mining pools pointed their pool to and from the SMLY depending on its difficulty. This led to complete havoc once Bitcoin prices rose in 2017, since the price of SMLY was strongly linked to BTC, mostly hovering at around 1 Satoshi. For this reason, a new wallet was set up with 5 mining algorithms, SHA256d, Groestl, Scrypt, Skein and Qubit. As with other similar coins, the hope is that the multitude of algorithms will reduce the likelihood that the chain will freeze up, but there are certainly mining pools available for all these coins.^{†††}

3. Cryptocurrency within an educational system

The Smileycoin was initially set up as a method to test reward mechanisms in the tutor-web educational system and this remains the coin’s primary purpose. At the outset this is like any other “funny money”, i.e. it is home-made and has no intrinsic value, just as Bitcoin was at its inception. However, to take this idea further, the SMLY



^{†††} Such as <https://theblocksfactory.com/>

logo and name are deliberately designed to indicate that this concept is primarily for fun, not for profit.

Rewards within the tutor-web system are tuned by giving students a pre-specified number of SMLY when certain levels of achievement are reached.

Hundreds of cryptocurrencies are listed on cryptocurrency exchanges⁺⁺⁺ which operate like stock exchanges and one currency can be exchanged for another in different markets. These generate market values, which are listed on open web pages^{\$\$\$}. As a result, SMLY can e.g. be exchanged for Dogecoin, which can be exchanged for Bitcoin which can be exchanged for US dollars.

Encouragement is displayed as students answer questions “Win x SMLY if you ace this lecture, bonus y SMLY for acing whole tutorial”:

Your grade: 9 ~ Win 10000 SMLY if you ace this lecture, bonus 100000 SMLY for acing whole tutorial

To implement these rewards, the tutor-web system now has its own SMLY wallet attached to it, which is topped-up from the pre-mine SMLY, and can be automatically distributed to students.

There are several places in the tutor-web in which students can earn SMLY whilst going about learning activities. The drilling system in tutor-web has been adapted so students get awards for: answering 8 questions, getting a top grade in a lecture and getting a top grade in all lectures in a tutorial, with the rewards for each typically going up exponentially.

Your grade: 9.75 ~ You have aced this lecture!

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Answered 6 questions, 6 correctly. Your most recent answers:-

1. ✓ 2. ✓ 3. ✓ 4. ✓ 5. ✓ 6. ✓

As with any other part of tutor-web, the rewards are parameterised, and can be adapted for each tutorial/lecture. Getting a top grade in a lecture demands good understanding of the

⁺⁺⁺ such as <http://c-cex.com> and <https://www.cryptopia.co.nz/>

^{\$\$\$} on sites such as <https://coinmarketcap.com/all/views/all/> where one can also find the Smileycoin

material, getting the top grade in the 7-10 lectures that make up a tutorial is correspondingly harder.

Tutor-web maintains a balance of SMLY earnt, but this balance is not automatically transferred. The offer is open for 2 years for a student to claim or redeem the balance, thus transferring the balance into any other SMLY wallet, either through tutor-web or directly from within the tutor-web wallet. The amounts involved (x and y above) are set within each lecture or tutorial, as discussed below.

Drilling is not the only tutor-web activity that has been given SMLY rewards. Well-performing students are asked to write questions, which will then be given to other students to answer and review. If a question is well-received by other students, this also comes with a SMLY reward. Finally there is a student-student chat system, where well-performing students can offer help to others, charging them SMLY.

When the SMLY was first introduced, an arrangement was made with a campus coffee shop, to permit cups of coffee to be purchased with SMLY. In order to provide further incentives, web pages have been set up, including <http://smly.is/> (in Icelandic), where students can buy specific products in the form of electronic coupons directly for SMLY. This approach implies that a hard-working student receives SMLY, which can be used to purchase physical goods.

4. Results

First responses and data summaries—When introduced to the SMLY, the students' first question asked tends to be sceptical, as in “what can it be used for”. Given the answer that one can purchase various coupons which give tickets to the cinema, domestic flights or airtime, the response of students tends to be incredulity.

Coins earnt		
Time	Lecture	Coins earnt
3/13/2017, 2:59:08 PM	/tutor-web/math/math050.1/lecture20	10000
3/13/2017, 2:57:59 PM	/tutor-web/math/math050.1/lecture20	100
12/15/2016, 6:04:20 PM	/tutor-web/math/math050.1/lecture10	10000
12/15/2016, 6:03:41 PM	/tutor-web/math/math050.1/lecture10	100
11/9/2015, 3:16:44 PM	/tutor-web/math/math104-Scalc/lecture75	1000
11/9/2015, 2:47:11 PM	/tutor-web/math/math104-Scalc/lecture55	1000
11/9/2015, 5:22:17 AM	/tutor-web/math/math104-Scalc/lecture45	1000
10/19/2015, 3:21:52 AM	/tutor-web/math/math104-4calc/lecture60	10000
10/19/2015, 10:39:02 PM	/tutor-web/math/math104-4calc/lecture45	10000
10/18/2015, 7:02:56 PM	/tutor-web/math/math104-4calc/lecture25	10000
10/18/2015, 6:48:43 PM	/tutor-web/math/math104-4calc/lecture25	1
10/10/2015, 7:14:18 PM	/tutor-web/math/math104-3calc/lecture72	1
9/25/2015, 2:27:16 AM	/tutor-web/math/math104-2calc/lecture55	1
9/25/2015, 1:39:43 AM	/tutor-web/math/math104-2calc/lecture54	1
7/20/2015, 1:04:24 PM	/tutor-web/math/math612.1/lecture40	1
1/20/2015, 2:49:56 PM	/tutor-web/stats/01/05	1
11/19/2014, 11:04:02 AM	/tutor-web/math/math121-1inalg/lecture45	1
11/19/2014, 10:52:28 AM	/tutor-web/math/math121-1inalg/lecture25	1
Total:		53208

Redeem coins	
You have 10100 smileycoins left to redeem. You have a maximum of 2 years before the offer expires.	
If you do not have a wallet yet to keep them in, you can get one from here .	
Unused SMLY will be donated to the Education in a Suitcase project. You can also do this now by pressing the donate button below. 8 million SMLY will buy one tablet computer for a student in Kenya.	
Enter your wallet ID below to redeem them:	
BNknfhwNububMY1gfk8e9MvH2CuxUafnEDg	

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[Donate to EIAS](#)
[Redeem your smileycoins](#)

The very short experiment at the end of fall semester, November 2014, demonstrated the feasibility of including SMLY in the tutor-web and allocating to students. The same course was next given in fall 2015 where it became clear that the initial reward settings were too low and they were therefore increased in 2016 with an aim for SMLY spending to achieve the 7-year target of 12.2 bn (1.7 bn/yr). By March 2017 a total of 2.8 bn SMLY had been allocated to students, somewhat below the target which would be 4 bn for the corresponding 28 months, but of the correct magnitude and can easily be adjusted.

The most extensive use of the tutor-web and SMLY has been in a particular course on introductory calculus.***** This course has some 450 entrants p.a., but in addition any other tutor-web users are also able to earn SMLY, and this currently includes students in high school and graduate school.

The actual rewards given to students can be set within each lecture or across an entire tutorial, in addition to the tutor-web defaults. The only hard limits on the amounts relate to the amount in the system, which imply the goal of spending an average of 1.7 bn/yr. There are quite a number of degrees of freedom in deciding how to set the rewards.

It is considered important for students to move from basic or passing knowledge to excellence and excellence should therefore give much higher rewards than mediocrity. Hence a reward of 1 and 2 M SMLY are typically given for acing a lecture and tutorial, respectively, whereas a much lower reward is given for simply answering a minimal number of questions correctly (possibly ending with a low grade).

A total of 3181 users had earned SMLY from November 2014 through February 2017. These users had earned a total of 2.8 bn SMLY and redeemed 666 million or 24%. It is thus seen that only a small number of students actually redeem their coins, but some students have indeed used their SMLY to purchase movie tickets and a discount at the domestic airline (through smly.is).

The fact that few students redeem their SMLY may partly be because most students do not get large sums as rewards. Thus, although over 500 students have been awarded 1 million SMLY or more, the value of this is of the order of \$10 (using “typical” exchange rates of the time, 100 M SMLY=1 BTC=\$1000). Through March 2017, a total of 34 students had been awarded 25 million SMLY or more, and 25 of these students have redeemed (some of) their SMLY. As expected, students appear more keen to redeem their coins if they have more value.

***** STÆ105G/STÆ108G at the University of Iceland, from 2014 onwards.

Abuse issues—Three cases of abuse or attack have been detected. In each case a student was found to have set up multiple email accounts and repeatedly aced one or more introductory lectures, typically lectures with a relatively small set of exercises, and subsequently transferred the SMLY to a wallet. This is an obvious potential abuse of the system. In these cases the email addresses were obviously connected as were the recipient SMLY addresses. Here, daily monitoring of rewards indicated a deviation in the amount redeemed. This was followed by an investigation into the email addresses corresponding to all wallet recipients of recent extractions of SMLY from the system. As it turned out, all the email addresses were very similar and not only were the SMLY addresses few but they were also linked to each other through transfers. A simple email to the student's addresses was sufficient to stop the first abuse case, but did not stop the second or third attacks.

Although one might consider methods to either auto-detect this sort of abuse, or make it more difficult, it is also clear that an attacker could also come up with alternative attack schemes, which would thwart simple detection methods so a different approach is needed. The on-line tutor-web wallet only stores a small portion of the available SMLY and this puts a hard limit on how many SMLY might potentially be stolen from the system. Further, the total allocation to students and the amount they redeem are monitored by humans. Since discrepancies are rare, they are simply checked manually. In effect the main guard against abuse is to limit the content of the tutor-web wallet to a magnitude which will sustain a “run on the bank” by those students who have already earned SMLY. Losing this amount merely corresponds to students redeeming what they own and is a small portion of the available premine.

The second attack was by a fairly determined student who used multiple email accounts and repeatedly solved the same fairly simple drills, always redeeming to the same SMLY address. A few emails presenting evidence were sufficient to stop this user, who initially tried to maintain multiple personalities.

The third attacker was much more elaborate and intent on exploiting the system, using over 200 email addresses and working throughout the entire tutor-web, solving math problems across multiple lectures and tutorials in several languages. As before, the emails were easily linked, as were the (few) SMLY addresses. Email correspondence had no effect on this user's behaviour and changes in SMLY reward levels merely moved this person to new - and harder lectures. Since this occurred during summer and outside the school years, all tutor-web parameters could be changed to random settings within very wide ranges. This was done in order to use the abusers to evaluate their responses, i.e. conduct an experiment on the abusers. Simultaneously a reCAPTCHA was installed and a handful of other measures were undertaken as well, including coordinating with the only exchange operating at the time to freeze the perpetrator's assets.

Somewhat unfortunately these changes were enough to stop the abusers so to date there is not enough data on how the parameter settings affect the abuser's behaviour.

Redeemed coins, diagnostics and price trends—Multiple tools are available to track and diagnose various aspects of cryptocurrencies. Thus, publicly available blockchain explorers can be used to investigate blocks and transactions and various sites list coin value, averaged across exchanges.

At the end of fall semester, 2016, an interesting downward trend in prices was observed, coinciding with the time when calculus students would be completing their studies, redeeming their SMLY and selling them^{††††}.

SmileyCoin Charts



With relatively few students wishing to redeem their coins some action was needed to avoid non-redeemed coins accumulating in the tutor-web system. First, an option was implemented where students can donate their SMLY to Education in a Suitcase, along with a time limit of two years during which students can redeem their SMLY. Secondly, at the end of the two year period any non-redeemed SMLY will be automatically donated to EIAS.

In fall, 2016, the opportunity was used to introduce not just the SMLY but also Education in a Suitcase in the aforementioned calculus course. The response, in the form of applause, was very uncharacteristic for a calculus course. It appeared quite clear that the mere existence of

Redeem coins

You have 10100 smileycoins left to redeem. You have a maximum of 2 years before the offer expires.

If you do not have a wallet yet to keep them in, you can get one [from here](#).

Unused SMLY will be donated to the Education in a Suitcase project. You can also do this now by pressing the donate button below. 8 million SMLY will buy one tablet computer for a student in Kenya.

Enter your wallet ID below to redeem them:

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^{††††} From <https://coinmarketcap.com/currencies/smileycoin/>

EIAS, along with the implicit student participation in the project through the SMLY, had a positive impression on many students. As a result, some students decided to donate their earned SMLY during the semester, resulting in a total of over 50 M SMLY in donations to the EIAS project in 2016.

5. Discussion

The traditional reward mechanisms in education have ranged from a pat on the back or a smiley on the student's drawing through exam grades, but experiments have also been conducted using hard currency, e.g. in the form of paying students for grades or for time spent. The approach presented here is to define an electronic coin for rewarding performance within an electronic educational system, and ensure that the coin can subsequently be used outside the system.

The results reported in this paper demonstrate that it is perfectly feasible to bring cryptocurrency into the classroom. Results to date also imply a variable speed of adoption by students, where a few early adopters embrace the coin, others use it for donations but most still ignore the rewards.

If an electronic currency does not have enough utility then owners are expected to simply sell their coins on a currency exchange, where its price will drop as a result. It is therefore imperative to have several uses available so students have alternatives to dumping the SMLY. The approach to distribute the coinbase partially to large wallet holders is being tested to see whether the resulting interest rate will suffice to avoid or counteract coin dumps.

One untapped potential of the SMLY is in the Education in a Suitcase project. Since EIAS is used in places like Kenya where a family may only have a single dollar a day for subsistence, a very different perspective opens up. In particular students who earn \$1 in a short period of time may find new incentives opening up along with a potential for a new level of encouragement from an environment with no tradition of education.

During these first years of developing SMLY rewards, the main goals have been simple system tests and qualitative evaluations of students' responses. A part of the system development has been to set rewards so they very roughly match the target of about 1.7 M SMLY p.a. Having achieved this, there are several next steps. The primary step is of course to investigate the effect of reward magnitude on learning and learners' behaviour. Another one is to tweak the rewards so as to reduce the effects of abuse. Ideas from the SMLY forum may lead to reward multipliers for students who indicate active SMLY participation by registering their wallet addresses within the tutor-web.

Future work includes enhanced services, both economical and otherwise: Services being tested include sending text messages to addresses, through the current blockchain without

modification to existing code. Given that dividends are paid only to addresses with a high associated amount, one can also envisage users wanting to group together to reach the minimum amount and to split the rewards. This can be implemented through a peer-to-peer lending mechanism, with requests for loans being advertised through text messages within the block chain. Finally, projects on the drawing board include schemes for tipping or donating using QR codes in public locations.

Acknowledgement

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In addition to SMLY project development and programming by the authors, computer programming has been undertaken by a large number of part-time staff and students, with the major individual contributions from Sandra Rós Hrefnu Jónsdóttir, Ívar Örn Ragnarsson, Andrea Björk Björnsdóttir, Ólafur Georg Gylfason, Dagur Tómas Ásgeirsson, Friða Snædís Jóhannesdóttir, Aníta Kristjánsdóttir and Hannes Kristinn Árnason.

Considerable feedback on SMLY development has been obtained from a number of colleagues, particularly Anna Helga Jónsdóttir.

Author Contributions

GS and JL both contributed to the manuscript preparation and have overseen teams of programmers implementing the SMLY. JL has programmed the entire current version of the tutor-web, including parameters controlling the SMLY allocation to students and question allocations in the drills. Within the experiments listed, GS has defined parameter values to be used in given classrooms and analysed the results.

Conflict of Interest

The authors JL and GS are the primary developers of the Smileycoin. GS has actively traded SMLY on various exchanges.

^{####} http://sjodir.hi.is/rannsoknasjodur_haskola_islands

^{#####} <https://en.rannis.is/funding/research/icelandic-research-fund/>

^{*****} <http://mareframe-fp7.org/> European Union FP7 grant agreement no.613571

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