Incentive Mechanisms for Crowdsourcing Platforms

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Abstract. Crowdsourcing emerged with the development of Web 2.0 technologies as a distributed online practice that harnesses the collective aptitudes and skills of the crowd in order to reach specific goals. The success of crowdsourcing systems is influenced by the users' levels of participation and interactions on the platform. Therefore, there is a need for the incorporation of appropriate incentive mechanisms that would lead to sustained user engagement and quality contributions. Accordingly, the aim of the particular paper is threefold: first, to provide an overview of user motives and incentives, second, to present the corresponding incentive mechanisms used to trigger these motives, alongside with some indicative examples of successful crowdsourcing platforms that incorporate these incentive mechanisms, and third, to provide recommendations on their careful design in order to cater to the context and goal of the platform.

Keywords: Crowdsourcing · Incentive Mechanisms · Reputation · Gamification

1 Introduction

Recently, there has been an ongoing interest in crowdsourcing (CS), a practice which emerged with the development of Web 2.0 technologies and capabilities [1]. The term "crowdsourcing" derived from the combination of the words "crowd" and "outsourcing" and is attributed to Jeff Howe [2]. As Howe wrote in 2006, CS is *"the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined network of people in the form of an open call"* [3] Since then, CS has evolved and it can be found in many diverse manifestations leading to various definitions that differ based on the author's perspective. In a recent study examining 40 different definitions on CS, it was concluded that *it constitutes a distributed online process that requires the participation of the crowd for the accomplishment of specific tasks* [4]. CS has already been successfully applied in many areas [5], from business projects [6] to non-profit initiatives [7]. Some examples include "crowdfunding" platforms (e.g. Crowdrise), platforms for civic engagement (e.g. Changemakers), and Open Innovation projects (e.g. Innocentive and Innovation Challenge [8]). CS can also be distinguished in participatory (based on users' directly provided input), as the examples above, and *opportunistic* (based on data indirectly provided by users' mobile devices, e.g. location info), such as Waze and Health Map's Outbreaks Near Me.

Successful CS systems are dependent upon the participation of the users and their continuous involvement. The reasons for participating in CS systems stem from a

adfa, p. 1, 2011.

broad spectrum of motives, such as altruism, social motivations, and monetary rewards [2]. However, as Zhao & Zhu [1] noted, there is a need for more research to be conducted on the various types of the crowd's motivations, since they vary greatly depending on the CS context. Therefore, a more in-depth understanding of user motives could enable the design of appropriate incentive mechanisms that would eventually promote sustained user engagement in CS platforms. As regards any pertinent research, a number of studies that focus on user motives for participating in various types of CS platforms (e.g. [5, 6], [9, 10, 11]), was identified. There are also studies addressing specific incentive mechanisms used in CS, such as reputation systems [12, 13] and gamification [14, 15]. However, there is a lack of studies that offer a holistic overview of all related user incentives and incentives mechanisms commonly applied in CS, as well as impediments and practical implications that should be taken into account when designing these mechanisms.

Towards this direction, this paper aims at: (a) examining user motives and corresponding incentives for participating in CS platforms; (b) investigating the incentive mechanisms that trigger these motives, as well as indicative CS platforms that make use of them; and (c) concluding on some practical design recommendations according to the context and goals of the CS platform. The particular study is of an interdisciplinary nature, since it draws both from the field of Motivational Psychology, examining the concepts of motivation and motivational factors, and Computer Science, researching and presenting various design mechanisms that activate user motives and encourage participation in CS platforms.

The rest of the paper is structured as follows: Section 2 presents the methodology of the particular review followed by a thorough analysis of the theoretical framework regarding user motives and incentives. Section 3 delves into the incentive mechanisms that are currently being applied in CS systems, while Section 4 highlights the issues that should be taken under consideration in the design of effective incentive mechanisms. Finally, this paper is concluded in Section 5.

2 Methodology & Theoretical Framework

2.1 Methodology

For the particular literature review, searches were made in numerous databases, including ACM Digital library, Google Scholar, ResearchGate, JSTOR, IEEE Xplore, etc. The authors first examined relevant research on user motives and incentives for participating in CS systems, and, afterwards, they reviewed and categorized the incentive mechanisms used in CS platforms and mapped their correspondence with relevant motives and incentives. For the needs of this study, a large number of CS platforms was reviewed and categorized according to the incentive mechanisms they incorporate and some prominent examples of successful CS platforms were selected in order to present the incorporated mechanisms. Based on this analysis, the authors concluded on several issues that should be taken into account when designing these incentive mechanisms, followed by useful design recommendations that could improve the overall user experience, as well as increase user loyalty.

2.2 Theoretical Framework

As already mentioned, the success of a CS system depends upon the sustained participation of the users, which, in turn, relies greatly on their motives. For this reason, in this section, we present some fundamental notions regarding user motivation, in order to understand what makes people willing to participate in online CS environments.

In the field of motivational psychology, a person who is activated in order to achieve a goal can be characterized as motivated, whereas a person who is uninspired to act is commonly referred to as unmotivated [16]. Motives can be internal (innate human needs), or external (situations that trigger these needs) [17]. In accordance with the Motive-Incentive-Activation-Behavior Model (MIAB), in a specific situation a suitable incentive will cause an individual's corresponding motive to be activated and lead, as a consequence, to the manifestation of a particular behavior [9].

As regards any specific motives for participating in CS environments, these may vary greatly depending on the participant, the situational context, as well as the system itself. Based on the studies of [2], [9], [18] we identify the following motives relevant to CS environments: (i) *learning/personal achievement*, (ii) *altruism* (iii) *enjoyment/intellectual curiosity*, (iv) *social motives*, (v) *self-marketing*, (vi) *implicit work*, and (vii) *direct compensation*. Learning/ personal achievement, altruism, social motives, and enjoyment/intellectual curiosity can be considered intrinsic motives, and are also in line with Maslow's pyramid of needs [4], according to which the two higher needs are self-esteem (including confidence, achievement, and the respect of others), and self-actualization (including creativity, morality, and inner potential) [19].

Following the aforementioned MIAB model, we look into the appropriate incentives that would appeal to the user motives we identified. Actually, each motive can be activated by one or more incentives. A suitable incentive for "learning" would be the *access to the knowledge and feedback of experts or peers*. "Altruism" constitutes the intrinsic motivation to help the community without personal benefit [2], and, thus, can be activated by having the opportunity to *contribute for a good cause*, and by *receiving feedback* concerning the impact of personal contributions. "Enjoyment" refers to the intrinsic motivation to perform an activity simply for the *sheer enjoyment and satisfaction* derived from that action [16] and intellectual curiosity is activated by having the opportunity to meet *new people* and explore *new places and situations*.

"Social motives" can be activated by various incentives, including the will to *attain social status* and *respect by organizers and peers* [9], as well as *present a good social image* according to the values of the online community [20]. Moreover, they may be influenced by the *initial interactions* a newcomer experiences with the online community [21], and can be increased by *presenting personalized social information* to participants [22]. For "self-marketing", *career options* are a decisive incentive especially for volunteers with specialized skills. For example, programmers contributing to open source software may be motivated by career concerns [23], since they have the opportunity to "advertise" themselves by demonstrating their knowledge and skills [9]. "Implicit work" is relevant to the so-called *passive CS*, as it is performed by the user as a *side effect* of accomplishing another task (e.g. the ESP game, reCAPTCHA), or by *contributing information* to third-party websites, even unknowingly

(e.g. AdWords, social media [24]). Therefore, it will be excluded from our incentives/ incentive mechanisms analysis. Lastly, "Direct compensation" can be differentiated between token and market compensation: the first usually constitutes something desirable, such as a *small monetary prize* or *token*, whereas the second involves *higher payment* [2].

In order to "trigger" the aforementioned incentives, several incentive mechanisms have been designed to elicit and sustain user participation in CS platforms. We have sorted them into four main categories, consisting of: reputation systems, gamification, social incentive mechanisms, and financial rewards and career opportunities. In the following figure we present the correspondence between motives, incentives and incentive mechanisms, as well as several CS platforms that make use of them. More specifically, user motives are placed in the middle inner circle, each one with a different color; suitable incentives for each motive are mentioned in the outer circles, using the same color with the corresponding motive. They are mapped to the incentive mechanisms that sustain them, depicted on the four corners of the image. Examples of CS platforms are strategically placed according to the incentive mechanisms they implement. For example, Waze was placed between Social Incentive Mechanisms and Gamification, since it incorporates both social and gamification elements.

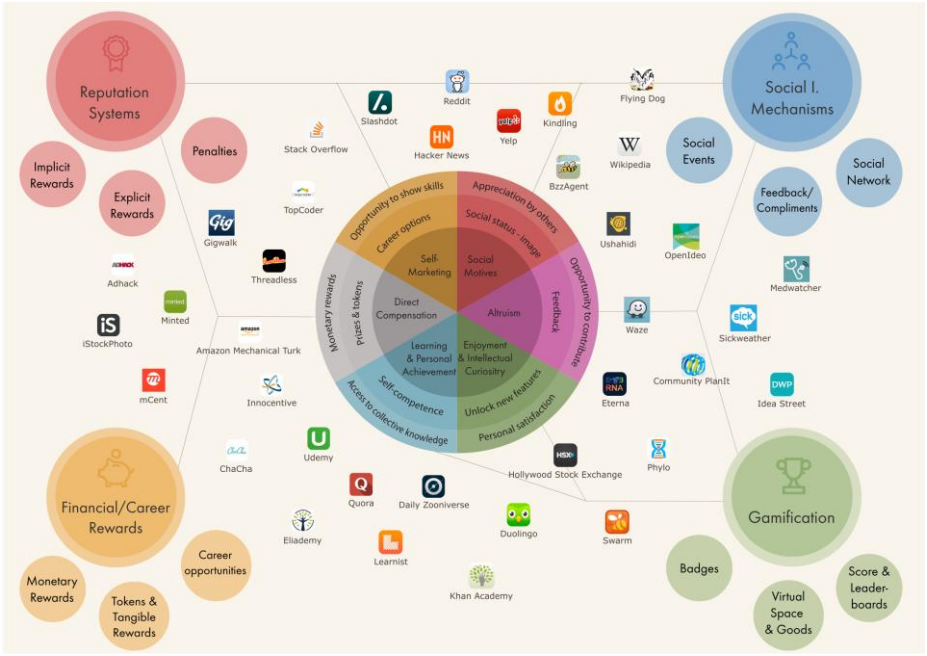

Fig. 1. User motives, incentives & incentive mechanisms

3 Incentive Mechanisms

3.1 Reputation Systems

Reputation systems are commonly encountered in CS platforms for increasing user participation and quality of contributions. Usually, the platform's users rate other users based on their behavior, and the reputation system combines these ratings to form cumulative assessments of their reputation. Reputation can be measured in discrete or continuous values and the mathematical model (metric) that aggregates ratings can be based upon several different methods, from simple summation and average of ratings to fuzzy logic or probabilistic models [25]. In this section, we describe different reputation metrics that are used according to the CS platforms' goals.

In CS news websites, such as Reddit, Slashdot, and Hacker News, we observe similar reputation metrics with minor but notable differences. On these websites, where the content is mainly user-generated, users accumulate reputation points, called "Karma", based on the ratings of their submissions (posts and comments) and their voting activity on other users' submissions. These reputation systems differ on their levels of "strictness" as regards down-voting and subtracting points from a user's reputation score. Reddit's reputation mechanism sums a user's post and comment karma separately, generating two karma scores based on the number of up-votes minus down-votes. On Hacker News, a user's karma is also calculated similarly. Hacker News differs in that users cannot down-vote posts until they reach a karma score of 500 points, so that they can be considered credible enough to do so. Lastly, on Slashdot, a user's karma is calculated as the sum of up-votes and down-votes on her comments, and is also affected by other things, such as acceptance of her submissions. It also influences the starting score of her comments on the platform: every comment is initially given a score of −1 points for users with low karma, 0 for anonymous users, +1 for registered users, and +2 for users with high karma. An even more strict approach is used by the Q&A platform Stack Overflow; users can build reputation slowly earning reputation points up to a certain daily limit by having their questions and answers voted up, their answers marked as "accepted", etc. [12] and loose reputation points by having their questions and answers voted down, their posts flagged as spam or offensive many times, and even when they vote down on other users' answers. That way, the platform tries to prevent malicious acts and urge users to think twice before down-voting an answer.

Reputation metrics can also take different forms than aggregating ratings. In Amazon Mechanical Turk (AMT), for example, a crowdsourced Internet marketplace, the reputation score of a participant ("worker") is essentially the rate of her approved "Human Intelligence Tasks" (HITS) to those submitted. This rate demonstrates the ability to complete tasks successfully; however, there is no mechanism to detect unfair user scores [13]. Conversely, the reputation of an employer ("requester") is an important motivator for workers to participate and put more effort into their work. For that reason, Turkopticon, a third-party reputation system which gives workers the opportunity to rate requesters based on four aspects of their behavior (Communicativity, Generosity, Fairness and Promptness) [26], was created. On the other hand, in

TopCoder, a CS platform which hosts regular contests relevant to design and development, the reputation score of contestants is calculated with a more sophisticated algorithm that takes into account their prior history, their expected performance, as well as their performance as compared to that of other contestants [27].

So far, we have described several approaches to assess a user's reputation. Apart from the reputation metric, reputation systems include some kind of reward for users with high reputation and/or penalties for users with very low reputation. *Explicit rewards* can consist of qualifications upon completion of tasks (e.g. AMT), special badges that prove contribution to the community (e.g. Stack Overflow), privileges in site management (e.g. Stack Overflow), more "moderation points" (e.g. Slashdot), or the right to down-vote (e.g. Hacker News). *Implicit rewards* include respect from the community, career opportunities (e.g. TopCoder), and acknowledgement of their credibility which gives them greater chances of being elected as moderators. Since user rewards often span from gaining badges to social status in the community and career opportunities, reputation systems are often combined with the incentive mechanisms that will be described in the next sections.

On the other hand, *penalties* could consist of blocking users with low reputation from accessing future tasks (e.g. AMT), ban them from posting temporarily (e.g. Slashdot) or posting to specific channels on the platform (e.g. Reddit), and suspend their accounts for a specific period of time that can be increased with subsequent suspensions (e.g. Stack Overflow). Reputation systems can also incorporate mechanisms to prevent malicious behavior, like filtering out posts based on the number of down-votes or user's reputation (e.g., Hacker News, Slashdot), allowing users to post in limited time windows (e.g. Slashdot), and concealing the algorithm used to calculate reputation scores in order to prevent system manipulation [28].

3.2 Gamification

Recently, there has been an increasing interest in the potential of "gamification", which can be defined as "the use of game design elements in non-game contexts" in order to improve user experience and engagement [29]. Such game design elements, also known as "game mechanics", include self-elements, such as points, achievement badges, levels, and time restrictions; social-elements, such as storylines, leaderboards, and interactive cooperation [30]; and can also include the virtual space and goods, as well as virtual gifts [31]. Prandi et al. [14] also mention status (titles that indicate a user's progress) and roles (role playing elements).These game mechanics let users develop their own skills, be creative, and feel competent, while experiencing an often social and enjoyable activity, and motivate them by rewarding their efforts and providing appropriate and timely feedback. Thus, gamification corresponds successfully to intrinsic motives such as enjoyment and social recognition [15], [32].

Gamification is frequently encountered in successful CS platforms and applications. Some notable examples of CS platforms that incorporate the majority of the aforementioned game mechanics include the language learning and crowdsourced translation platform Duolingo, the educational platform Khan Academy, and Foursquare's local discovery and sharing app Swarm. Notable game elements implement-

ed in Duolingo are: (a) levels of progress that sustain user engagement by offering small scale goals; (b) immediate feedback and helpful tips; (c) clear goals and rules that motivate users to continue; and (d) intuitive and friendly interface that helps creating an immersive experience [33]. Other incorporated game elements are player "lives", scores based on performance, leaderboards and competition between friends, as well as virtual currency which users can use to buy virtual goods or gift it to other users [33]. These virtual gifts promote participation and a sense of privilege and community between users [34]. Khan Academy incorporates achievements, user avatars, badges, levels, content unlocking, and "boss fights" (final tests before leveling up). Notable aspects are that there is no competition between users [32], no social interactions, and user profiles are private by default [15], supporting users' isolation on the platform. Swarm, on the other hand, is a gamified application heavily based on the social interactions between users, indicating that gamification can appeal to social motives and be used in conjunction with social incentive mechanisms as well. Swarm incorporates several game mechanics, such as points ("coins"), badges ("stickers"), and social ranking with leaderboards between friends, motivating users to participate and perform more check-ins [35]. The reason this platform was not claimed under social incentive mechanisms (Sec. 3.3) is that, as argued in [36], Swarm is quite enjoyable even without the social interactions, as a single player "sticker game", offering clear progress and rewards to the users.

Other CS contexts where gamification has been applied include CS platforms in which users participate primarily for altruistic reasons, e.g. civic engagement [37]. Often, these platforms exploit user generated data gathered automatically from sensor-enabled mobile devices (e.g. smartphones). Gamification here can provide extra incentives to participate, apart from the initial intrinsic motivational factors. Waze, for example, is a GPS application for crowdsourced traffic monitoring. Users participate either by sharing traffic and accidents reports or by contributing road data using their smartphones. Waze incorporates gamification elements, such as avatars, points, leaderboards, achievements, levels, badges, and social interactions.

Finally, there are also successful CS *"games with a purpose"*; they are online games which constitute a *"general mechanism for using brainpower to solve open problems"* and can be applied in various, diverse areas, such as computer vision, security and content filtering [38]. Foldit, e.g., is a puzzle game and at the same time a CS platform, in which players try to fold the structures of selected proteins in the best possible way, and researchers then analyze the highest scoring solutions to apply them in real world scenarios. Foldit attracts engaged users through achievement, social interaction, and immersion, supported by several game mechanics [39]. Other CS games with a purpose include the ESP Game [38] and Phylo [40].

3.3 Social incentive mechanisms

Social motives often play a major role for participating in CS platforms. For example, it is argued [20] that in online reviewer platforms social image and reviewer productivity are positively correlated, while in online ideas competitions participants want to receive positive reactions regarding their skills [18]. Having a good social image is

very important for participants in online communities, who want to be perceived as intelligent, fair, wealthy, and "good", in general [20].

In order to trigger these social motives, many social incentive mechanics that act as enablers of social interactions, giving users the chance to showcase their skills and gain social status in the community can be implemented (e.g. specialized mailing lists, discussion fora, provision of feedback/compliments functionalities, invitations to events, etc.). At the online review community Yelp social interactions and a sense of community contribute greatly in sustaining user interest and participation. Users can connect with friends or meet fellow-minded people, plan events, exchange "compliments" and learn more about a reviewer's personality and taste from her profile page. Yelp members care about presenting a good social image to friends and other Yelp community members by being active and contributing many quality reviews [20].

On the other hand, on the aforementioned Swarm app, users can import their contacts from social media, such as Facebook, meet new friends with similar interests, see their nearby contacts, and exchange messages. The application supports social recommendations through tips, as well as checking-in with friends and adding photos to check-ins. As Cramer et al. [35] mention, these "social-driven" check-ins support friendship, togetherness, and identity. Social incentive mechanisms are also used in Zooniverse, a "cityzen science" platform where users can contribute to novel research in different areas and share the discussion boards with researchers in order to explore and analyze data. Additionally, there are fora, blogs, meme generators and even competitions created by users, which makes participation much more fun [41]. In Wikipedia, a free web-based collaborative encyclopedia, editors claim and receive credibility and recognition in the community, as a reward for their contributions, by displaying lists with articles they have edited on their user pages [42].

3.4 Financial Rewards & Career Opportunities

Another incentive mechanism commonly applied in CS platforms is financial rewards, which trigger extrinsic motives like market and token compensation. Financial rewards are used in order to compensate for the lack of social rewards and intrinsically enjoyable tasks [43], as it not always feasible to replicate situations in which people participate voluntarily, but they can also be used in combination with intrinsic incentives. An example of CS using monetary rewards to incentivize the crowd is InnoCentive, a company that offers cash awards for the best solutions in research and development problems. Here, apart from intrinsic motivations, the desire to win the monetary prize is also a significant motivational factor for the participants [44]. Apart from payment, financial rewards can also comprise small tokens, various prizes, and free access to services and products. For example, the mCent application gives users free Internet access for each sponsored application they download and try out.

Monetary rewards are often encountered in CS platforms combined with reputation systems. One example is the aforementioned Amazon Mechanical Turk, in which workers receive payment upon completion tasks and after approval by the requester or by the platform (automatically). Requesters can also give bonuses in case they are very satisfied with the performance of the workers. Similarly, Gigwalk is a CS mobile

application that allows users to find quick jobs in their area posted by retailers and consumer brands; it also matches users with jobs according to their performance score. In other cases, monetary rewards are combined with career and self-marketing opportunities for professionals. In iStockPhotos, an online stock imagery website, users submit their work and receive commission for each sale. Brabham [6] concluded that even though learning and peer recognition are important motivational factors for contributing work to iStockPhoto, the main incentive for participants is the opportunity to sell their work. Similarly, Threadless is an online community of artists, as well as an e-commerce website. Designers can submit their work for public vote by the online community, and receive royalties, cash and gift cards if their designs are selected. Apart from the important financial incentive, users may also participate for self-marketing reasons and higher employability [5]. WiseStep helps employers and recruiters to find high quality talent faster and cheaper, by referrals from the crowd. The participants are, in turn, motivated by having the opportunity to build a strong professional network and win monetary awards by referring their friends. Lastly, an example of CS platform which combines financial rewards and reputation systems is the afore-described TopCoder. Since many technological companies sponsor TopCoder competitions in search for talented developers, and taking into account that reputation in TopCoder is directly linked with performance, it is argued that reputation here is also of important economic value [27].

Finally, it should be mentioned that financial incentives are also important in prediction markets, which give users the opportunity to buy and sell shares based on the outcome of events (e.g. the non-profit Iowa Electronic Markets). The invested amounts are small but they still constitute an important incentive to participate, along with any intrinsic incentives. The aforementioned CS platforms and the most prominent incentive mechanisms characteristics they incorporate are depicted in Figure 2.

Fig. 2. Incentive mechanisms elements and CS examples

4 Incentive Mechanisms Design Recommendations

Upon examining the design of the aforementioned incentive mechanisms, the authors concluded that there are several issues that should be taken into consideration; the most significant ones are going to be presented here, categorized according to the incentive mechanism they correspond to, and summarized in Figure 3.

Reputation Systems. First of all, as regards the reputation metric, it is argued that it should be chosen according to the goals of the system and the desired user behaviors [45]. Activity statistics are suitable for building trust between users and supporting member matching, cumulative metrics can increase user loyalty to the platform, and scoring mechanisms facilitate the promotion of quality content. In CS platforms that seek to promote collaboration, public scores should only be positive; negative scores should be avoided or at least be private to avoid competitive spirit. In order to support diversification and the varying skills of the participants, user scores and ranking should be based upon several different dimensions of contributions. Both short term and long term reputation could be included in order to encourage newcomers and provoke their interest with smaller scale goals, while increasing user loyalty [28].

Much attention should be paid to avoid reputation bias due to unfairly positive or negative ratings. In particular, presumed unfair ratings could be excluded based on their statistical properties or the reputation of the rater [45] and domain knowledge filtering methods [25]. Furthermore, they could be cross-checked through meta-

moderation schemes, e.g. "rating the raters", or prevented by trying to induce truthful ratings with the use of external rewards, such as financial rewards [25], and the use of anonymous rating schemes [45]. On the other hand, it has also been noticed that malicious users frequently change their identity on the platform and start all over again. One way of preventing that is by mapping virtual identities to the real ones; however, this approach may discourage users from joining the platform in the first place, or, in case their identities are disclosed, giving negative feedback to other users [25], contributing in increasing positive bias. A possible solution could be keeping user identities known only to the reputation system and using community moderation to identify malicious acts and users [25]. In order to support the reputation system's fairness, a common approach is to prevent users from building high reputation very fast (e.g. Stack Overflow), while also allowing them to lose it quickly if at some point they stop contributing or behave maliciously [46]. Lastly, to prevent manipulation of the reputation system, many platforms do not reveal details of their reputation algorithms, even though this practice entails the danger of diminishing the perceived fairness of the system and, consequently, user trust. A middle road could be followed, in which some information regarding reputation score aggregation is disclosed to users and some is unknown (e.g. Reddit, Hacker News).

Gamification. Gamified systems should also be carefully designed, as applying game elements without any consideration for their latent usefulness leads to nothing more than "pointsification" [47]. As a negative consequence, pursuing points may become the primary goal of the participants [41]. Moreover, by merely incorporating game elements into tasks, they would not necessarily become more interesting and engaging. Instead, game mechanics should be implemented very carefully depending on the specific situational context and the targeted users. Leaderboards, e.g., may raise unnecessary competition in CS environments that promote collaboration and target implicit motives. Even in competitive environments, they should be used with caution because they might demotivate newcomers and other low ranked users. Alternatively, short-term leaderboards that allow users to compete on a short time window with the same chances to win by resetting scores every week (e.g. Swarm's weekly leaderboards), or leaderboards including multiple ranking dimensions, could be used. Other alternatives could be customizable leaderboards, allowing participants to choose whom they compete with, or leaderboards that adapt to the user in order to provide optimal motivation levels [37]. As a general recommendation, competition "should be available, but easy to be ignored" [37] (e.g. in Yelp leaderboards are not easily accessible from the main page). Lastly, as regards the inclusion of other social-elements in gamified platforms, the platform's goals should also comprise gamified "collective goals" and not only individual user goals to emphasize on cooperation [41], and highlight social achievements [15].

Social incentive mechanisms. Elements that could increase competitiveness should also be used carefully on platforms that target social motives, since those platforms' primary goal is to support friendly social interactions and collaboration. Design elements that enhance participatory behavior and allow users to connect with

others should be included instead. Such elements include online discussion groups, social networks, and functionalities that enable user feedback and the wider distribution of content in the social network. It should also be mentioned that the initial interactions newcomers experience on the platform and the feedback they receive from older members can also affect the levels of their future participation. Indeed, newcomers that have access to their connections' contributions and receive feedback on their activity learn by observation what is feasible and socially acceptable on the platform faster, and they contribute more themselves [48]. Thus, the design of such platforms should facilitate social learning, social interactions such as photo tagging, and support newcomers with different behavior and engagement levels on the platform (e.g. active versus inactive users) [48].

Designers should also consider the fact that security concerns and self-representation issues may arise on social platforms. Swarm (Foursquare) users, for example, are often concerned about the privacy of their check-ins, as well as their social image which, according to their opinion, may be negatively affected by checking in at particular places [36]. A way to deal with these issues is to give users the opportunity to keep their profiles and activity on the CS platform private and/or separate from their social media accounts (e.g. Facebook, Twitter).

Financial rewards/ Career opportunities. As regards offering monetary rewards in CS systems the main advantage of this approach is that it is "relatively low cost", since most participants consist of amateurs, scientists, or individuals wishing to apply their skills or pass their free time [49]. However, it should be noted that there is skepticism concerning financial incentives, since extrinsic rewards can decrease people's intrinsic motivation [16]. Moreover, financial rewards may result in short term gain but in the long run they may decrease engagement [39]. Additionally, they do not necessarily lead to better contributions. Indeed, studies regarding participation in Amazon Mechanical Turk have indicated that higher payment had a positive effect on attracting more workers and increasing the quantity of the completed work, but did not lead to increase in its quality and accuracy [43], [50]. Quinn & Bederson [18] also mention that participants may be more tempted to cheat the system in order to increase their reward. A recommended approach for incorporating financial rewards is to employ small monetary rewards as an initial motivating factor, and then utilize other tangible rewards, such as prizes, in conjunction with gamified achievements on the platform to achieve sustained engagement [37].

General design recommendations. Lastly, various other underlying design decisions that appeal to all of the aforementioned incentive mechanisms were also identified. Most of them are relevant to the user interface (UI), including the presentation and placement of incentive mechanisms elements, such as reputation score and visual indicators. For example, profile pages are usually very carefully designed. The profile page of a Stack Overflow user, e.g., contains useful information, such as her reputation score, which is clearly visible on top of the page, recent activity on the platform and even a tag cloud with the subject categories that the particular user is participating in. Suitable placement of information in order to be easily accessible is also an im-

portant issue. In Stack Overflow, recent job postings are displayed next to a question, visible to visitors and registered users alike. That way, developers who are interested in displaying their skills to potential employees or they are actively searching for a job can be more incentivized.

Compelling and intuitive UI, as well as appropriate feedback that indicates a user's progress towards mastery, can also encourage and sustain user participation. In both Duolingo and Khan Academy, learners have access to visual indicators of their progress, such as charts and diagrams based on their activity statistics. Their score is always visible on top of the page. In Khan Academy, the contents of a learning topic are displayed in a sequential list with icons that indicate both the type of content (e.g. video, challenge) and the progress of the learner. Positive feedback based on scores that are percentiles of the larger group can also make players feel more empowered and positive about their skills. In the Great Brain Experiment, a CS game in which players participate in experiments that test their cognitive abilities, they might be told that they have better impulse control as compared to 90% of the population. Lastly, the UI should indicate to the newcomers various ways to contribute, as well as any potential benefits from their participation, in a simple and comprehensive way. In MovieLens, e.g., users are explained that the more ratings they provide the more personalized recommendations they will get, as the system "learns" their preferences.

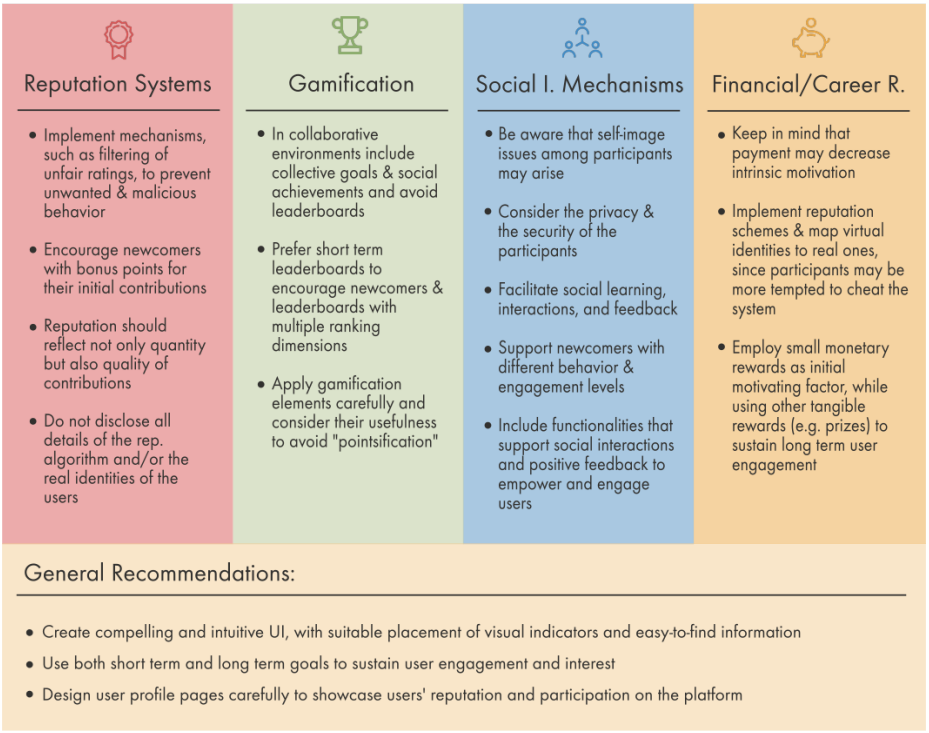

Fig. 3. Practical recommendations for the design of incentive mechanisms

5 Conclusions

This paper provided a holistic overview of the incentive mechanisms used in CS environments and categorized them under four main directions, i.e., (i) reputation schemes, (ii) gamification practices, (iii) social mechanisms, and (iv) financial rewards and career opportunities. The different incentive mechanisms were analyzed and mapped to different intrinsic and extrinsic user motives and incentives, providing, that way, useful guidelines regarding the selection of incentive mechanisms according to the target users (and their motives) and the context of different CS platforms. Additionally, relevant examples of various CS platforms and applications implementing these mechanisms were discussed and the authors highlighted certain issues that should be taken into consideration for the successful implementation of such mechanisms and concluded on several practical design recommendations.

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