# Exploring Mobile End User Development: Existing Use and Design Factors

Abdallah Namoun, Athanasia Daskalopoulou, Nikolay Mehandjiev, *Member, IEEE*, and Zhang Xun

**Abstract**—Mobile devices are everywhere, and the scope of their use is growing from simple calling and texting through Internet browsing to more technical activities such as creating message processing filters and connecting different apps. However, building tools which provide effective support for such advanced technical use of mobile devices by non-programmers (mobile end user development or *mEUD*) requires thorough understanding of user needs and motivations, including factors which can impact user intentions regarding mEUD activities. We propose a model linking these mEUD factors with mobile users' attitudes towards, and intent of doing mEUD, and discuss a number of implications for supporting mEUD. Our research process is user-centered, and we formulate a number of hypotheses by fusing results from an exploratory survey which gathers facts about mEUD motivations and activities, and from a focus group study, which delivers deeper understanding of particular mEUD practices and issues. We then test the hypothesized relationships through a follow-up enquiry mixing quantitative and qualitative techniques, leading to the creation of a preliminary mEUD model. Altogether we have involved 275 mobile users in our research. Our contribution links seven mEUD factors with mEUD intentions and attitudes, and highlights a number of implications for mEUD support.

**Index Terms**—Human factors in software design, mobile environments, models and principles, requirements/specifications

## 1 Introduction

Mobile devices, including smartphones and tablets, are everywhere. A recent survey showed that in 2013 over 73 percent of the population across 65 countries owned a smartphone, and over 33 percent owned a tablet [1]. Mobile devices are being used primarily to browse the Internet, listen to music, play games, make calls, send messages and emails, and take photos [2]. More active forms of engagement are also emerging, such as creating blogs, "rooting" mobile devices (i.e., giving administrative rights to users) and also creating mashups which basically are software applications that bring together a number of data feeds and services into one place [3], [4]. All these activities take place directly on mobile devices, so a growing number of researchers are providing specialized tools to support them. However, the majority of the proposed tools are technology-driven, especially those focused on creating mashups by integrating a number of separate service components. The result is that such systems are difficult to understand and use, especially by non-technical users [4].

Supporting software development and development-like activities by non-technical users is a focus of End User Development (EUD) [5], [6]. EUD aims to create tools and methods, which enable ordinary users who are not programmers to develop software applications without programming [5]. User-centric approach is often followed in the development of tools and notations, and a growing number of papers integrate the design of EUD tools with wider studies of user mental models and factors motivating EUD activities and uptake, ensuring alignment between tools, context and motivation [7], [8], [9]. However, EUD research has so far focused on understanding software development activities using desktop and laptop applications. Indeed, areas covered include developing web applications [10], spreadsheets [11], service composition (mashups) [8], [9], [12], and games [13], yet apart from a couple of studies ([14] and [48]), understanding which factors impact software development activities using mobile devices has received little attention from the EUD community up to now.

The present paper attempts to bridge this gap, and undertakes the challenge of surveying and exploring evidence into mobile EUD (mEUD) activities, models and factors influencing mEUD uptake. Effective support for mEUD requires understanding of existing mEUD practices and answering a number of research questions. Do end users actively create mobile apps, scripts and mashups using their mobile devices? What are the barriers hindering them to perform mEUD? What are the contextual and personal factors impacting the uptake of mEUD activities? Answers to these questions will underpin a theoretical model for the uptake of mobile end user development activities, and will provide the foundation for a set of requirements for mEUD-supporting tools.

To answer these questions, we accomplished a holistic user-centered research process. In the initial exploratory stages we formulated a number of hypotheses regarding the factors impacting mEUD uptake by fusing the results of a fact-finding online survey with 51 mobile users and the results of a focus group study with eight mobile users, a

- *A. Namoun is with the Islamic University of Madinah, Medina 170, Saudi Arabia. E-mail: a.namoun@iu.edu.sa.*
- *A. Daskalopoulou, N. Mehandjiev, and Z. Xun are with the University of Manchester, Booth Street West, Manchester M15 6PB, United Kingdom. E-mail: {a.daskalopoulou, n.mehandjiev}@manchester.ac.uk, xun.zhang-2@student.manchester.ac.uk.*

*Manuscript received 23 Jan. 2015; revised 3 Jan. 2016; accepted 28 Jan. 2016. Date of publication 22 Feb. 2016; date of current version 21 Oct. 2016. Recommended for acceptance by M. Burnett.*
*For information on obtaining reprints of this article, please send e-mail to: reprints@ieee.org, and reference the Digital Object Identifier below.*
*Digital Object Identifier no. 10.1109/TSE.2016.2532873*

stage delivering a deeper understanding of mEUD factors and user concerns. We then tested these relationships using a follow-up study comprising a quantitative survey, with 209 mobile users, and a focus group study, with seven users, to confirm the design factors of the proposed model and explore further issues raised by the analysis of the survey. The results of the final focus group study were not used to validate the relationships discovered earlier, but rather to check the consistency of these relationships and achieve a deeper understanding of the links between the factors. Each participant took part in only one of the research stages to eliminate any learning effects or influences on their views and perceptions about mEUD.

This paper makes two key research contributions. First, it uncovers the practices of mobile users in respect to developing software apps using mobile devices, with a particular focus on the underlying challenges which hinder mEUD adoption. Second, it proposes a preliminary theoretical model to predict the uptake of software development using mobile devices by a subset of mobile users (particularly students), with a focus on the factors facilitating such uptake.

The remainder of this paper is organized into eight sections. Section 2 reviews related research in the area of end user development with a particular focus on mobile devices. Section 3 outlines and justifies the research methodology adopted in this research. Sections 4, 5 and 6 describe the results of our user studies. Section 7 discusses the key findings of the studies and enumerates the limitations of this work. Finally, section 8 summarizes the work undertaken, highlights some implications from the findings and proposes a plan for further work in the area.

## 2 Related Research

This section presents the literature on the area of end user development, reviews research works on mEUD, and discusses a number of technology acceptance models (TAMs).

### 2.1 End User Development

Lieberman [5] defines End User Development as a process, which "*enables users, who are non-professional software developers, to create, modify, or extend a software artefact, using a set of methods, techniques, and tools*". As such, EUD provides an alternative way for enhancing user participation in software development by allowing everyday users to shape systems based on their own needs.

EUD thus has the potential to be beneficial for both organizations and consumers. Organizations can benefit from the creative power of end users; using it to increase their productivity and client satisfaction [16], whilst consumers can gain more control by being involved in the development process [17]. However, altering systems causes concerns about correctness, consistency, security, privacy, user errors and incompleteness of information [5], [18]. Further insights into the risks and benefits of EUD activities are available elsewhere [6], [7], [8].

Numerous research works have explored EUD activities on primarily desktop and laptop applications including the development of spreadsheet applications [11], web applications [10], composite services [8], [12], [19], mashups [12], [19], and games [13]. However, research on mEUD is still in its infancy. Indeed, the scientific community lacks knowledge about the mental models, attitudes and enabling factors for EUD in mobile contexts. Our research endeavors to bridge this gap and establish first research directions in the area. We are informed by our previous work on attitudes and enabling factors behind EUD [7], [8], [9], [19], [20], yet re-contextualizing this knowledge in the domain of mobile devices required us to start afresh with an exploration and fact-finding stage before moving to model building and finally to the validation stage of our research process.

### 2.2 End User Development Using Mobile Devices

Software development using mobile devices is becoming increasingly popular. Users demonstrate a growing interest in services offered by mobile devices, and express the need for customizing their own [24]. Although there are a number of studies that propose different tools to enable software development, research is limited on how these tools are used or who their users are.

A review of the mEUD literature unveiled three types of EUD activities performed by mobile users:

1. Creation of mobile apps: A number of tools are available for creating mobile applications directly from a mobile device. Cuccurullo et al. [21] introduced MicroApp, which allows users to create apps by dragging-and-dropping different actions without having to specify the dataflow between apps. Similar tools include Puzzle, a framework that allows users to visually create apps [22], MobiDev [23], Microservices [24] and TouchDevelop [48].
2. Creation of mashups: Mashups allow users to combine multiple services from different sources. Cappiello et al. [25] developed MobiMash, which enables end users to create mobile mashups directly from their mobile devices.
3. Creation/modification/extension of games: Mobile gamers engage in various activities such as writing scripts to unlock extra features of a game, or even developing their own animations and games using tools like Catroid [26].

In the literature, there is inherently an assumption that the ultimate goal of mEUD environments is to provide a balance between what technology has to offer and what users need in order to realize the full potential of ubiquitous computing [17]. However, to date research on the subject has been limited; hence, further studies are required in order to realize the full scope and potential of mEUD activities.

### 2.3 Technology Acceptance Models

MEUD is a relatively new research area, and studying existing technology acceptance models helps understanding how mEUD is currently adopted by early users, and the enabling factors that affect its successful adoption. Technology acceptance has been studied extensively in different contexts, resulting in a number of interesting models, including: Diffusion of Innovations Theory (DOI) [27], Technology Acceptance Model [28], Theory of Planned Behavior (TPB) [29], Theory of Reasoned Action (TRA) [30] and Unified Theory of Acceptance and Use of Technology (UTAUT) [31]. Such models enable the prediction of adopting new

technologies by users, for example in [20] TRA was fused with previous work on benefits and drawbacks of EUD in organizational context [7] and applied to the domain of EUD activities related to task management.

In our research, the factors discussed in these models will help us understand the uptake of mEUD activities. Indeed, technology adoption and user studies are focusing more and more on mobile devices; for instance, mobile health [32], mobile government [33], and mobile banking [34].

Technology acceptance models stipulate that individual's intention to use new technologies is a key predictor for adopting these technologies. Intention to use a new technology is affected by various constructs. For instance, the UTAUT model proposed four key constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions [31]. In the mobile context, all of these constructs have been shown to influence intention to use mobile services [34], [35], [36], [37], [39]. Influence of effort expectancy decreases after long periods of usage. Influence of social environment has been observed of being greater at the first stages of interacting with a new technology in voluntary settings [38]. Moreover, behavioral intention is indirectly influenced by four constructs: gender, age, experience, and voluntariness of use. This model has been extended by various new constructs, such as Perceived Playfulness/Enjoyment, Perceived Risk, Trust and Attitude [34], [36], [37]. However, none of these constructs were used to measure intention to conduct mEUD activities, nor there exists a model which discusses the enabling factors of mEUD.

## 3 Research Methodology

This research is exploratory in nature. It aims to uncover whether a subset of mobile users, particularly students, do develop software applications and write scripts using their mobile devices, the type of mEUD activities they perform, the challenges that hinder their involvement in mEUD, and their attitudes towards design factors that may affect mEUD. Our literature review showed that the area of mEUD remains in its early infancy and lacks foundations. Given the expected significant differences between the target domain of mobile computing, and the domains where we have run previous studies: desktop and service-oriented EUD [7], [8], [9], [16], [20], and also the limited availability of studies targeting directly the use of EUD on mobile devices (mEUD), we opted for an exploratory approach with the aim of developing an EUD model in the mobile context to help create and test inferences and theories. Indeed, we followed a mixed-research approach (i.e., both qualitative and quantitative) for development purposes [40], where the results of the first method shape the development of the next method and so forth. Fig. 1 depicts the overall methodology of this research, comprising three sequential, interrelated stages: fact-finding stage, in-depth understanding stage, and model testing stage. In our methodology, we strategically planned to first learn about the practices and type of mEUD activities that currently exist (i.e., fact-finding stage), and then discuss these practices in-depth with mobile end users (i.e., in-depth understanding stage) leading to the formulation of a set of hypotheses, which are finally tested as part of a preliminary model for mEUD (i.e., model testing stage). In order to explain to the participants

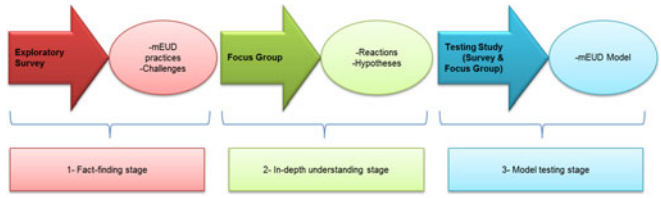


Fig. 1. Research methodology.

of each stage what we termed as mEUD, we gave examples of possible mEUD activities such as customization of mobile apps, rooting mobile devices, creating email filters amongst others (see Fig. 4). We then asked each participant in the focus groups to provide examples of activities in which they were engaged.

Consequently, we employed two different yet complimentary research methods, a survey and a focus group study throughout our research. In essence, a survey is a statistical form of acquiring data from a specific population about a particular topic, with a strong emphasis on making statistical inferences about relationships between various design factors [41]. However, for the purpose of the first stage of our research we sought to gather information that describes the behavior, practices, and activities of mobile users in respect to mEUD. This was achieved through an exploratory online survey, which acted as a fact-finding research tool to establish practices and challenges in the mEUD domain. The outputs of this fact-finding stage were essential for undertaking the next stage.

A focus group is a qualitative form of research where a group of people, ranging from five to eight, are instructed to discuss their perceptions, views, practices, and attitudes towards an interactive product or system [42]. In general, focus groups are advantageous as they can be used to grasp details and unveil avenues not possible using traditional quantitative research methods. The focus group study in the in-depth understanding stage aimed to follow-up and discuss in detail any interesting results that emerge from the fact-finding stage of the exploratory survey. In this focus group, we used a video example demonstrating mEUD using an app in order to facilitate understanding of mEUD usage and engage the participants in discussions; the demonstrated app was not meant to be tested nor was it meant to capture problems experienced by participants when undertaking mEUD. To alleviate any biasing effect, we asked the participants of the focus group to start their discussions with examples of any mEUD activities in which they have been engaged. In effect, the second stage allowed us to gain a deeper understanding of the mental models of a subset of mobile users and gauge their direct reactions towards mEUD activities. The results of the first and second stages gave rise to a list of hypotheses about potential mEUD uptake factors.

Finally, we tested the mEUD hypotheses in a follow-up testing study using a quantitative survey and a focus group in the model testing stage. The survey aimed to test statistical inferences between the hypothesized factors and actual uptake of mEUD, leading to the creation of a preliminary model of mEUD uptake. However, the focus group was conducted not to validate the model but rather to triangulate the results, exploring issues arising and confirming the

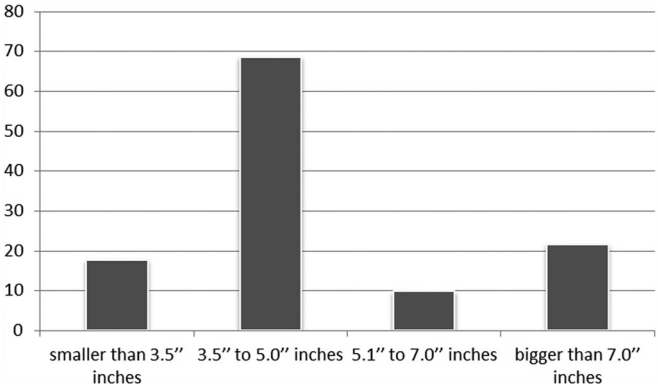


Fig. 2. Screen size of mobile devices owned.

emergent mEUD factors separately rather than the model as a whole. As such we looked for and identified examples from participants' discussions that support the factors of our mEUD model.

## 4 Stage One: Fact Finding

We designed and distributed an exploratory survey to mobile users to explore existing mEUD activities. Reaching out to different populations allowed us to gain a broader understanding of the type of activities performed, and of the factors that motivate or constrain users. The online survey was sent to a large number of people globally via a number of channels such as social media (e.g., Facebook, Twitter, LinkedIn), forums (e.g., XDA developers, AndroidPIT, The StudentRoom, etc.) and emails with the survey's URL. Respondents were entered into a prize draw to win a £50 voucher.

### 4.1 Questions Formation and Results Analysis Technique

Our survey design was based on our understanding of the mEUD landscape. It included exploratory, open-ended questions focusing on:

1) demographic information and type of mobile devices owned,
2) motivations for conducting mEUD activities,
3) types of mEUD activities users undertake,
4) problems users face when performing mEUD,
5) support users receive to conduct mEUD,
6) ways of social support to uptake mEUD, and
7) reasons for not performing mEUD activities.

The survey was not set to test pre-defined hypotheses, but rather to acquire knowledge about this new research area. We used the 'thematic analysis technique' to analyze the answers to the open-ended questions of our survey. Thematic analysis involves reading the textual data collected, identifying patterns in the data, codification of those patterns, and then interpretation of the structure and the content of those patterns [43], [50].

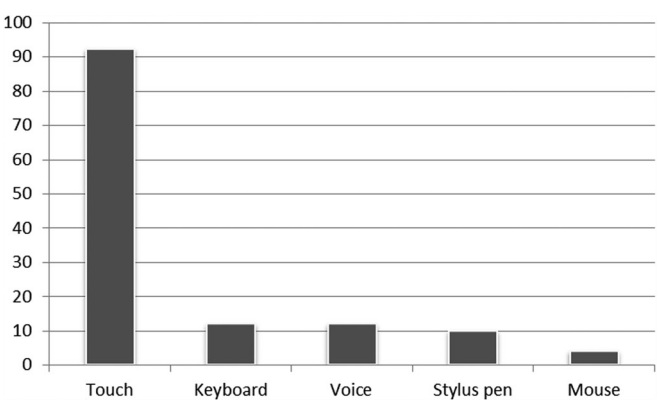


Fig. 3. Interaction style used to interact with mobile devices.

TABLE 1
Motivations for Conducting mEUD Activities

| Theme Name | Times Observed | Occurrences per user | |
|---|---|---|---|
| | | End user developers | IT experts |
| Gain advantages | 42 (41 percent) | 1.7 | 1 |
| Improved User Experience | 33 (32 percent) | 1.2 | 1.33 |
| Fun | 10 (10 percent) | 0,3 | 0,66 |
| Mobility | 10 (10 percent) | 0,43 | 0,16 |
| Other | 8 (7 percent) | 0,3 | 0,33 |
| # Total | 103 | – | – |

### 4.2 Profile of Participants

In total, 51 participants (26 males and 25 females) completed the online survey. We received 20 answers for the motivation question, 18 answers for the problems question, 19 answers for the support question, 15 answers for the ways of social support question, 24 answers for the 'reasons for not performing mEUD' question. All answers we received were usable, and most of these answers contained multiple entries which explains the high number of themes in some of the below tables. Twenty seven had conducted mEUD activities previously, while 24 had never performed such activities. Their age ranged from 17 to 35 years, with an age mean of 23. Out of all the participants, 37 were from the United Kingdom, and the remaining were from Greece, Sweden, Bulgaria, China, Malaysia and the United States. Based on their IT background, 42 participants (82 percent) had no formal IT education, whilst nine participants (18 percent) were IT experts (i.e., had formal IT education).

### 4.3 Results

The survey gathered information about the features of mobile devices owned by our participants. We discovered that 44 (86 percent) participants owned a smartphone, 6 (12 percent) owned a tablet and 5 (10 percent) owned a regular mobile phone. Only four participants owned both a smartphone and a tablet. The most popular operating system was Android (55 percent), followed by iOS (41 percent). The screen size of 69 percent of the mobile devices our participants used ranged from 3.5 to 5.0″ (see Fig. 2). Finally, 47 (92 percent) participants used 'touch' to interact with mobile devices as shown in Fig. 3.

The thematic analysis technique enabled us to identify the reasons that motivated participants to engage in mEUD activities. In Table 1, we report the number of times each theme has occurred in total, along with the average number of theme occurrence by end user developers and IT experts.

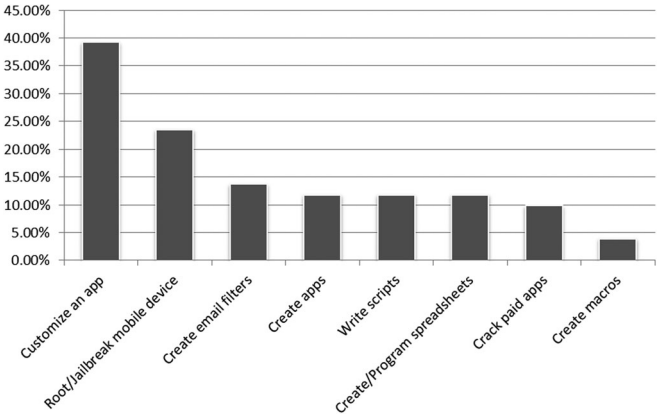


Fig. 4. Types and percentage of mEUD activities performed by users.

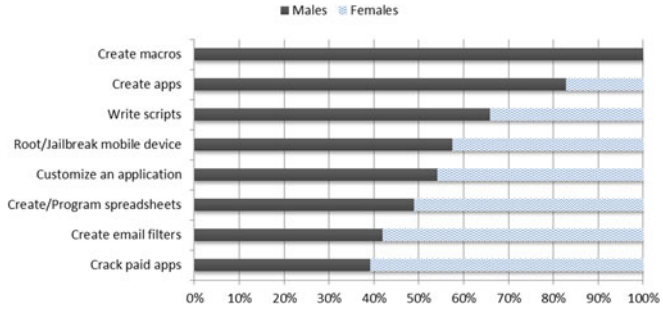


Fig. 5. Types and percentage of mEUD activities performed by gender.

This is to discover how end user developers and IT experts differ in perceiving the factors that influence uptake of mEUD. Four major themes emerged from the analysis of 103 statements as listed in Table 1.

The first motivator for engaging in mEUD was gaining some sort of advantage or benefit (41 percent of the themes). This is often a tangible gain. Examples included saving or earning money, saving time, gaining experience, having an advertisements shield, having free access to apps, and gaining access to advanced functionalities in their mobile devices. Participant 23 (no IT education) reported: *"Potential of evolving technology, mobile advertising opportunities, and the application market opportunities"* or Participant 10 (no IT education) reported: *"I get what I like for free"*. Participant 16 (no IT education) stated: *"Improved functionalities, improved performance"*. The second motivator for performing mEUD was acquiring a better overall user experience (32 percent of the themes). This is an intangible or psychological gain. For example, Participant 24 (no IT education) reported: *"I wanted to make my phone unique, and personalize it"*.

The third motivator was fun/enjoyment (10 percent). Mobile users emphasized that fun and enjoyment are a key to creating software applications using mobile phones. For instance, Participant 22 (IT expert) reported: *"It's fun, I can do things easier"*. The forth motivator was mobility (10 percent). Mobile users are able to conveniently conduct EUD activities whilst on the move and without the need for other resources. This is a facilitating condition, which is infeasible for desktop stations. For example, Participant 20 (no IT education) stated: *"It allows me to travel without paper holding"*. While Participant 12 (no IT education) characterized engaging in such activities as *"unavoidable"*, since it facilitates accessibility; more precisely she reported: *"It's unavoidable, since it is easier to use my phone when I can't find a PC"*.

In summary Table 1 points out the relative importance of tangible benefits as a motivating factor for end user developers, whilst for IT experts the importance shifts to improved user experience and fun.

We identified eight types of mEUD activities mobile users perform as follows. Fig. 4 summarizes these activities in order of frequency.

1) Customize mobile apps: users customize existing apps, where customization includes changes to the user interface of their apps such as the colors and layout.
2) Root/Jailbreak the mobile device: through rooting their mobile device (e.g., overclock, jailbreak) users can modify or delete system files. This enables users to take control of their devices and become power users.
3) Create email filters: users organize their emails based on specific criteria depending on their needs. These rules filter incoming emails and apply certain actions (e.g., delete, classify) to them.
4) Create apps: users create dedicated mobile applications and sell them in the online market place.
5) Write scripts: users write scripts for various purposes; for instance to unlock extra features of a game.
6) Create/Program spreadsheets: spreadsheets are used by users with different levels of experience; they facilitate analysis of data using advanced mathematical formulas.
7) Crack paid application: this generally involves unlocking commercial applications as a way of avoiding to pay for them.
8) Create macros: users create simple programs that perform a series of actions within a software, for instance a Word processor.

In respect to gender differences, males create more mobile apps and macros, write more scripts, and root their mobile devices more than females (Fig. 5).

Analysis of 49 problems, which our respondents encountered when conducting mEUD activities, revealed seven themes summarized in Table 2. The most frequently mentioned problem was the low self-estimate of respondents' ability to perform mEUD activities. For instance, Participant 17 (no IT education) reported: *"I do not have enough knowledge to conduct the development, fear of the system crashing"*, and *"It's complicated, I'm worried I might do something wrong"*. The second emergent problem was the hardware restrictions of mobile devices, for example, Participant 6 (IT expert) reported the following problems: *"Size of the device, internet connection issues, testing errors, touch screen operational issues, and battery life"*. The remaining problems were failure of performing an EUD activity in the past, time/resource consuming activities, security issues and lack of technical support.

In summary Table 2 suggests the relative importance of self-efficacy, past experiences, and effort expectancy as motivating factors for end user developers, whilst for IT experts the importance shifts mainly to hardware specifications of mobile devices.

In terms of the type of support end users rely on to perform mEUD activities five themes seem to emerge. Table 3

TABLE 2
Problems Hindering mEUD Uptake by Mobile Users

| Theme Name | Times Observed | Occurrences per user | |
|---|---|---|---|
| | | End user developers | IT Experts |
| Low self-efficacy | 14 (29 percent) | 0.6 | 0.33 |
| Mobile device hardware restrictions | 13 (27 percent) | 0.43 | 0.7 |
| Failure in the past | 6 (12 percent) | 0.24 | 0.16 |
| Time/Resource consuming | 5 (10 percent) | 0.24 | 0 |
| Security/Privacy | 3 (6 percent) | 0.09 | 0.16 |
| Lack of technical support | 2 (4 percent) | 0.05 | 0.16 |
| Other | 6 (12 percent) | 0.3 | 0 |
| # Total | 49 | – | – |

indicates that end users mainly sought expert help from Internet forums, search engines, specialized development websites, and official provider's website. However, they receive insignificant support from their social environment, e.g., friends. Forums were the primary source of mEUD support and learning. Participant 7 (no IT education) reported: *"I rely on Stackoverflow and XDA-Developers forums to assist with development"*. Apart from forums, individuals relied on search engines as a means to find support, for instance, Participant 17 (no IT education) indicated: *"Before rooting the phone, I googled a lot of information on forums and blogs about how to root. I also downloaded some files to help to root the phone"*. Moreover, participants found websites and blogs very useful to resolve mEUD problems, Participant 23 (no IT education) reported: *"Forums are absolutely brilliant when looking to understand gaps and issues in your code. However, I feel that sites like Udemy, Codeacademy and Skillshare are the future of software education as they have a non-linear and untraditional way of teaching people how to build apps and understand code (especially for back end development)"*.

In summary Table 3 suggests the relative importance of forums as a main source of mEUD support for both end user developers and IT experts. This was followed by the use of search engines for both groups. However, end user developers were more inclined to rely on the help provided by official providers in contrast to IT experts who relied more on the help of their friends. This result may be attributed to the self-efficacy of each group, where end user developers tend to trust experts more than themselves and their friends.

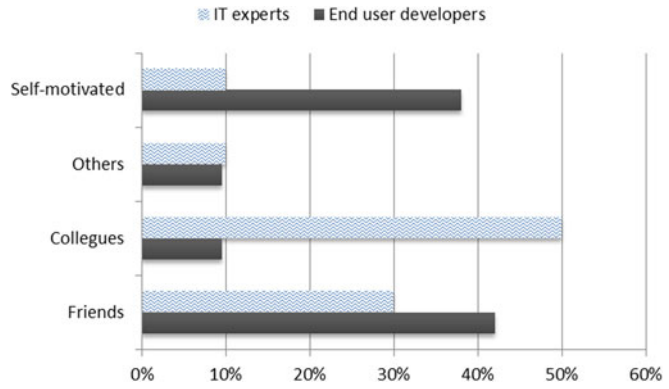

Fig. 6. Social influence to perform mEUD activities per IT background.

Next, we explored the influence of social environment on the uptake of EUD-related activities by users, as depicted in Fig. 6. In total, 42 percent of the end user developers were influenced by friends, 38 percent were self-motivated, and finally only 10 percent were influenced by their colleagues at the workplace. In contrast, 50 percent of IT experts were influenced by colleagues and 30 percent by friends. Fig. 6 shows that end user developers are mainly self-motivated and affected by friends to perform mEUD, whilst IT experts are influenced by their colleagues.

To perform mEUD, participants were encouraged by listening to their friends' experiences and learning the advantages they would get from EUD. For example, Participant 17 (no IT education) reported: *"I have an Android smartphone and sometimes it does not run very fluently. My friend suggested me to root my phone so I could uninstall some apps freely. I did and I find it really helpful"*. Moreover, participants were encouraged when someone actually showed them how to perform those activities. For example, Participant 20 (no IT education) reported: *"They show me how easy and flexible the applications are"*.

In summary Table 4 suggests the relative importance of EUD examples and tutorials as a motivating factor for end user developers, whilst for IT experts the importance shifts mainly to the demonstration of mEUD advantages. This demonstrates that end user developers learn by observing how others perform mEUD activities instead of tinkering and exploring.

Finally, we identified four primary reasons from 25 statements as to why students do not conduct mEUD activities, as summarized in Table 5. The main reason

TABLE 3
Type of Support Users Rely on to Perform mEUD

| Theme Name | Times Observed | Occurrences per user | |
|---|---|---|---|
| | | End user developers | IT Experts |
| Forums | 14 (48 percent) | 0.5 | 0.7 |
| Search engines | 6 (21 percent) | 0.2 | 0.33 |
| Specialized development websites | 5 (17 percent) | 0.2 | 0.16 |
| Official provider | 3 (10 percent) | 0.14 | 0 |
| Friends | 1 (3 percent) | 0 | 0.16 |
| # Total | 29 | – | – |

TABLE 4
Ways of Social Support to Uptake mEUD

| Theme Name | Times Observed | Occurrences per user | |
|---|---|---|---|
| | | End user developers | IT Experts |
| Demonstration of advantages | 7 (41 percent) | 0.2 | 0.5 |
| Illustration of how to do EUD by others | 4 (23 percent) | 0.2 | 0 |
| Sharing of previous EUD experiences | 3 (18 percent) | 0.14 | 0 |
| Other | 3 (18 percent) | 0.14 | 0 |
| # Total | 17 | – | – |

TABLE 5
Reasons Against Performing mEUD Activities

| Theme Name | Times Observed | Occurrences per user | |
|---|---|---|---|
| | | End user developers | IT Experts |
| Lack of technical skills | 9 (36 percent) | 0.4 | 0.16 |
| No need to perform EUD | 7 (28 percent) | 0.23 | 0.33 |
| Lack of interest | 5 (20 percent) | 0.2 | 0.16 |
| Lack of technical resources | 4 (16 percent) | 0.2 | 0 |
| # Total | 25 | – | – |

was lack of technical knowledge and skills to be able to master such activities; for example, Participant 43 (no IT education) reported: "*Because I don't have the technical capabilities to conduct advanced software development*". The second reason was lack of motivation, i.e., not needing to perform mEUD activities; the third reason was lack of interest to conduct such activities; for instance, Participant 36 (no IT education) reported: "*I have not yet felt inclined to do any of these activities*". The fourth reason was lack of technical resources.

In summary Table 5 highlights lack of technical skills and resources as the main reason against performing mEUD by end user developers, and lack of need and motivation to perform mEUD as the key reasons against performing mEUD by IT experts.

In summary, the exploratory survey with 51 participants revealed interesting insights about the motivations and underlying problems that hinder the uptake of mobile end user development activities as follows:

1) Mobile users are motivated to perform mEUD in order to achieve an instrumental or psychological gain. This seems to be a dominant mEUD factor (evidence from Table 1).
2) Mobile users, especially end user developers, are hindered from performing mEUD as a result of their low self-efficacy which may be a result of lack of technical skills (evidence from Table 2).
3) Expert support from specialized software development websites and forums encourages mobile users, especially end user developers, to perform mEUD activities (evidence from Table 3).
4) Mobile users are frequently self-motivated but are also inspired by their social environment (e.g., friends and colleagues) to perform mEUD (evidence from Fig. 6).

Key results from this exploratory survey were further discussed in the next focus group study, and supported by real experiences of mobile users.

## 5 Stage Two: In-depth Understanding

A focus group study was conducted in order to further explore the types of mEUD activities users undertake. We chose focus groups because they enable to collect different views about a certain topic and encourage interaction between participants which often leads to rationalization of these different perspectives [42]. They are different from any other type of group interviews as the interactions and discussions between group members are encouraged but controlled by a moderator to ensure focus on a specific topic [42]. In focus groups, the moderator manages the discussion ensuring participants focus on the topic by asking opening general questions, and encouraging them to discuss their views and rationalize them.

### 5.1 Procedure

Eight people took part in the focus group study. The authors sent an email with the details of the study to students across the university who then self-selected to participate in the focus group by replying to the email. We aimed for wide coverage and the distribution of IT Education in the target population was similar to the one we received back. The study lasted approximately one hour. The discussions were recorded for subsequent analysis. Participants were compensated with a £10 voucher each for their time.

Following a brief introduction, the focus group focused on discussing the subsequent aspects:

1) demographic information and type of mobile devices owned,
2) type of mEUD activities users undertake,
3) benefits/motivations for conducting mEUD activities,
4) problems users face when conducting mEUD activities,
5) support users receive to conduct mEUD, and
6) reasons for not performing mEUD activities.

It is worth noting that participants were shown a video of a mobile tool, the App.Cat [44], which enables the creation of mobile apps with the aim of initiating a group discussion around mEUD. The video demonstrated how a restaurant mobile app is easily created by a mobile user in less than 5 minutes. App.Cat makes use of various design templates which end users may choose from and customize to their needs using hand gestures. The focus of this introduction was on the general idea of mEUD rather than on specific user operations and mEUD techniques supported by App. Cat. Any potential bias introduced by this example was then alleviated by asking each participant in the focus group to describe their mEUD experiences, bringing other examples to the fore.

Again we used the 'thematic analysis technique' to analyze and interpret the data collected from the focus group. In our analysis, we sought to understand how users perform mEUD activities and what factors influence their decision making.

### 5.2 Profile of Participants

In total, eight people participated in our focus group study. Six (75 percent) participants had conducted mEUD activities, while the remaining two (25 percent) participants had never performed such activities before. The age of the participants varied from 23 to 30 years. Three (37 percent) participants were male and five (63 percent) were female. Based on IT background, we identified two groups of users; seven participants had no formal IT education, whilst one participant was an IT expert.

TABLE 6
Evidence of mEUD Motivations

| mEUD Benefits / Motivations | Evidence from discussion |
|---|---|
| Instrumental gains—Creation of business opportunities—Saving of money | ***Participant 3 (no IT education)*****:** *"It can save you the cost of hiring a programmer if you can do it yourself"*. ***Participant 5 (no IT education)*****:** *"AppCat is a very creative tool that can help businesses and individuals advertise themselves and also save or earn some money"*. |
| Psychological gains—Increasing self-efficacy | ***Participant 5 (no IT education)*****:** *"Before, I thought of creating my own application but I thought it would be very difficult, now I know that it isn't"*. ***Participant 5 (no IT education)*****:** *"Now that I have learnt how to do it I am not afraid about anything that might go wrong with my phone, I have experience"*. ***Participant 8 (no IT education)*****:** *"I would feel self-fulfilled if someone could download my application that I created"*. |
| Mobility | ***Participant 3 (no IT education)*****:** *"I use my phone everywhere and for everything, I only use my computer when I'm at home"*. ***Participant 2 (no IT education)*****:** said: *"I will always use my mobile phone when I'm on the road"*. |
| Rich capabilities of mobile devices | ***Participant 4 (IT expert)*****:** *"What I need to do with my laptop I can do with my phone and it is also more user-friendly"*. |
| Promoting sociability and support | ***Participant 7 (no IT education)*****:** *"Now I can help myself and also help a friend if they need to"*. |

TABLE 7
Evidence of mEUD Issues

| mEUD Issue | Evidence from discussion |
|---|---|
| Physical constraints of mobile devices | ***Participant 3 (no IT education)*****:** *"The screen size is too small, I need to have a big screen to see all the code, otherwise you have to scroll up and down and it's really annoying"*. |
| Lack of suitable interaction style (e.g., touch) | ***Participant 1 (no IT education)*** **said:** *"Selecting text is so much easier in a computer!"*. ***Participant 5 (no IT education)*****:** *"I feel better typing in a keyboard than a touch screen"*. |
| Negative past experiences | ***Participant 7 (no IT education)*****:** *"I stopped conducting EUD activities using my mobile phone, because in the past I had accidently locked it and I don't want this to happen again"*. |
| Inability to support dynamic and self-customization behavior for the created apps | ***Participant 3 (no IT education)*****:** *"This is exactly how you would design a webpage, it is really easy but you are limited to what the application can do, I would like to do more"*. ***Participant 1 (no IT education)*****:** *"It has static functionalities; the only dynamic feature is Facebook and Twitter"*. |
| No support for runtime look and feel | ***Participant 1 (no IT education)*****:** *"When you create an application you want to see how it is going to appear in different devices and with the AppCat you have no idea"*. ***Participant 2 (no IT education)*****:** *"I am confused about where photos or text appear within the application you create"*. |

### 5.3 Results

Six (75 percent) participants owned only a smartphone, and two (25 percent) participants owned a smartphone and a tablet. The most popular mobile operating system was iOS (55 percent), followed by Android (36 percent), and Symbian OS (9 percent). The screen size of mobile devices owned by our participants ranged from 3.5 to 5.0″ (89 percent), and from 5.1 to 7.0″ (11 percent). Finally, six (75 percent) participants used touch to interact with their mobile device, while the remaining two participants used a keyboard and voice respectively.

In the beginning, participants were asked to describe their overall past mEUD experience. Participant 1 (no IT education) reported that he had rooted his mobile phone for the first time a couple of weeks ago without having any prior experience. In doing so, he relied on expert online support: "*I hadn't done it before, but there are a lot of guides online which are very helpful. As long as you follow the instructions it's very easy*". However, he waited until the mobile phone's warranty became void to root his phone with the aim of customizing the user interface. This indicates that end user developers are concerned about the risks associated with mEUD. Also, Participant 5 (no IT education) had rooted her mobile phone without any prior experience as she was unable to perform certain functions. However, she described the rooting process as challenging: "*I found that something was wrong with my phone shortly after purchasing it, it made me really anxious and I had to learn by myself to root my mobile phone, it was very difficult*". Finally, those who do not conduct mEUD activities did not feel the need to do so; for example, Participant 9 (IT expert) said: "I have not yet felt inclined to do any of these said activities".

In regard to the motivations (Table 6), participants reported that mEUD would be useful for any type of business, and it could be used by people who have not done it before, or people without IT background (Participant 5 (no IT education)). Similarly, they argued that individuals can earn money by selling their applications on the Apple store or the Google market. Participants reported that 'being mobile' is a distinguished advantage of using mobile devices. Moreover, they reported that conducting mEUD activities helps them learn and boost self-efficacy. It also gives them a feeling of self-satisfaction.

The main issues hindering mEUD included physical constraints of mobile devices, such as screen size, interaction style, memory size, battery life and so on (Table 7). Moreover, participants highlighted that frequently their mobile devices crash, or run slow when processing a heavy workload. Participants prefer to use a keyboard and a mouse rather than typing on a touch screen. Participant 7 (no IT education) reported that she had stopped conducting mEUD activities because of a negative past mEUD experience. Moreover, participants highlighted other issues such as inability to create apps that support customization and dynamic behavior. Participants reported that there are no clear indications of how the created applications could work or look like at runtime.

TABLE 8
Evidence of mEUD Support

| mEUD Support | Evidence from discussion |
|---|---|
| Searching engines and dedicated forums | ***Participant 3 (no IT education)*****:** *"Google mostly and android developer forums, because you can search by phone or by operating system in order to find what you want".* |
| Consulting experts | ***Participant 3 (no IT education)*****:** *"After I find what I'm looking for, if the solution is very simple and I think I can handle it, I will do it. But if it is complicating and I feel there is a risk I will go to the official store to repair it".* |
| Relying on friends | ***Participant 5 (no IT education)*** **said:** *"I ask my friends, boys know a lot about those things!".*<br>***Participant 8 (no IT education):*** *"I will search online because electronic problems can always be located. For me it is also a chance to learn something, not only solve a problem and then if a friend has the same problem I can tell them how to solve it".* |

TABLE 9
Evidence of Ways to Encourage mEUD

| Ways to encourage mEUD | Evidence from discussion |
|---|---|
| Positive previous experiences | ***Participant 1 (no IT education)*****:** *"If you had a bad experience you would not do it again. However, if you changed something and it worked you would do it again".* |
| Support from experts | ***Participant 5 (no IT education):*** *"If there was better support from the official provider, I would feel safer, in case something went wrong".* |
| Fit for purpose apps | ***Participant 7 (no IT education)*****:** *"I would be more engaged if I could make my life easier, more exiting".* |
| Social influence | ***Participant 8 (no IT education)*****:** *"I will try a new application or a new system if my friends are using it as it will help me be more updated or more close to them".* |
| Perceived benefits-earning money | ***Participant 8 (no IT education)*****:** *"Participating in contests that I can earn some money or maybe find a career opportunity".* |
| Simplify EUD—support for drag and drop interfaces | ***Participant 2 (no IT education)*****:** *"Most people are not techy, it needs to become easier. For example applications could use a questionnaire format asking people whether they want more speed and so on".*<br>***Participant 1 (no IT education)*****:** *"Over simplify the interface, an application that you can just drag and drop, no programming required".* |
| Enabling co-design of apps by involving final end users | ***Participant 8 (no IT education)*****:** *"More people will get involved and more software will be co-designed by professionals and customers. Customers may become the most important designers".* |

Various types of mEUD support were discussed by the participants (Table 8), such as the use of search engines and forums. Participant 7 (no IT education) said that she would first search on a dedicated website and then would google the problem. However, when there is a potential risk associated to performing mEUD, mobile users consult experts. Other participants rely on friends for support. Participant 8 (no IT education) reported that trying to find a solution online is a learning experience.

The participants were asked about what would encourage them to continue conducting mEUD activities in the future (Table 9). They reported that their previous experiences would shape their future mEUD behavior. There was also emphasis on the need for stronger support from the official provider, especially when something goes wrong. This introduces a sense of safety, thus reducing risks. Moreover, the participants emphasized the importance of applications that can facilitate their daily lives. Participants may be influenced by the people close to them and their social environment in general. Finally, earning money would encourage users to continue conducting such activities. Moreover, participants emphasized the need to abstract mEUD activities from technical details and implementations. One participant (Participant 8 (no IT education)) illustrated the importance of users as co-designers of the mobile devices they use.

In summary, the qualitative results of the focus group study, coupled with the results of the exploratory survey, emphasized the importance of some factors that may have a positive effect on the uptake of mobile end user development. These factors enabled us to derive a number of mEUD hypotheses as follows. We reference the source of each hypothesis from our studies.

*Perceived benefits of mEUD:*

*H1. Perceived benefits have a positive influence on the actual uptake of mEUD activities (Table 1, Exploratory Survey; Tables 6 and 9, Focus Group).*

*H1.1. Perceived instrumental gains have a positive influence on the actual uptake of mEUD activities (Table 1, Exploratory Survey; Tables 6 and 9, Focus Group).*

*H1.2. Perceived psychological gains have a positive influence on the actual uptake of mEUD activities (Table 1, Exploratory Survey; Table 6, Focus Group).*

*H1.3. Perceived instrumental gains have a stronger influence on the actual uptake of mEUD activities than perceived psychological gains (Table 1, Exploratory Survey; Table 6, Focus Group).*

*Perceived ease of performing mEUD:*

*H2. Perceived ease of performing mEUD has a positive influence on the actual uptake of mEUD activities (Tables 2 and 5, Exploratory Survey; Table 6, Focus Group).*

*Perceived fun of mEUD:*

*H3. Perceived fun has a positive influence on the actual uptake of mEUD activities (Table 1, Exploratory Survey; Table 8, Focus Group).*

*Features/Capabilities of mobile devices:*

*H4. Rich features of the mobile device have a positive influence on the actual uptake mEUD activities (Tables 2 and 5, Exploratory Survey; Tables 6 and 7, Focus Group).*

*Expert support:*

*H5. Expert support has a positive influence on the actual uptake of mEUD activities (Table 1, Exploratory Survey; Tables 8 and 9, Focus Group).*

*Social influence:*

*H6. Social support has a positive influence on the actual uptake of mEUD activities (*Fig. *6, Exploratory Survey; Tables 6, 8 and 9, Focus Group).*

*Self-efficacy:*

*H7. Mobile users with high self-efficacy are more likely to uptake mEUD activities than those with low self-efficacy (Tables 2 and 5, Exploratory Survey).*

*Technical background:*

*H8. Technical background has a positive influence on the actual uptake of mEUD activities (Table 5, Exploratory Survey).*

These hypothesized relationships were verified in a testing study to check their correctness and derive our mEUD model.

## 6 Stage Three: Model Testing

As indicated earlier, our testing study took the form of a quantitative survey including 209 respondents, and was then followed by a focus group study including seven mobile phone users designed to explore any inconsistencies or issues within the hypothesized relationships and support the factors of the model. We first start by describing the model testing survey and its results.

### 6.1 Model Testing Survey

We administered a model testing survey to statistically verify the hypotheses proposed and key constructs, and thereby create a preliminary mEUD model. The survey contained 15 questions to collect attitudes and perceptions of mobile users towards end user development using mobile devices. The questions, which fit with the constructs of our proposed model, were adapted from well-established technology acceptance models including Technology Acceptance Model [28], Theory of Planned Behavior [29], and Computer Self-Efficacy (CSE) [45] to ensure validity of collected data. Unlike in study one and two, in this model testing survey we had not collected qualitative data about the type of mEUD activities our participants performed as we were mainly interested in testing our hypotheses statistically and finding out which factors contribute towards mEUD uptake. Qualitative data about the type of mEUD activities would not help in asserting conclusions about the hypotheses of the model.

Due to the difficulty in recruiting a random sample that includes users with mEUD experience, we opted for convenience sampling [46], whereby we distributed the survey online via the mailing lists and offline to students at the University. This allowed us to gather responses from a good size sample and within a reasonable timeframe. To minimize non-response and bias, respondents were entered into a prize draw to win one of 3× £15 vouchers.

#### 6.1.1 Survey Design and Measures

The survey aimed to test the above hypotheses, and thereby captured information and measures about the following aspects:

- demographic information about the respondents including age, gender, IT proficiency, mEUD experience, and mobile devices owned, and
- attitudes towards constructs that could constitute the preliminary model.

Initially, the survey was piloted with 32 respondents, leading to the refinement of the survey questions to ensure validity of the measures. The constructs and their corresponding questions are represented on Fig. 7.

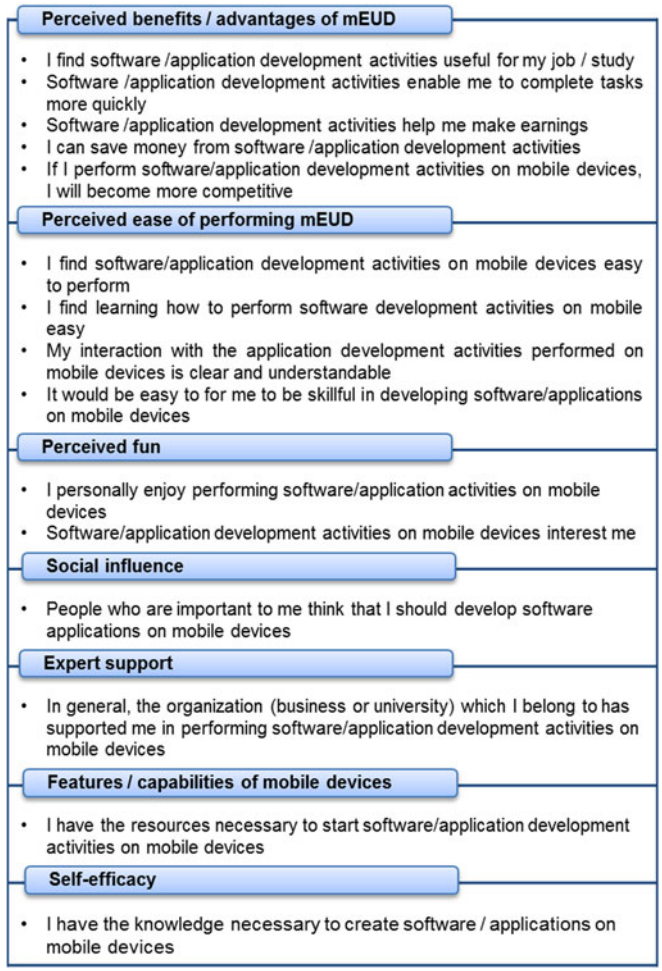


Fig. 7. Design of the Testing Survey.

Respondents rated their agreement with the above questions, which used a five-point Likert scale, ranging from '1= Strongly Disagree' to '5 = Strongly Agree'. These ratings enabled the testing of our hypotheses and model.

#### 6.1.2 Profile of Participants

In total, 209 university students (116 males and 93 females) completed the model testing survey over a period of eight weeks. All answers were usable. Only 32 respondents had a significant experience in mEUD and 177 had no mEUD experience. 193 (92 percent) respondents were 18 to 25 years old. All respondents owned a smartphone or a tablet, running Android (43 percent) or Apple (iOS) (42 percent) as indicated in Table 10.

#### 6.1.3 Results

The reliability test Cronbach's alpha showed a sufficient internal consistency ( $> 0.70$) for all composed constructs of the model. Next, we ran a Pearson correlation test to explore the possible associations and their strengths between the key constructs of the model and actual uptake of mEUD by our respondents. Results showed that all constructs are significantly correlated ($p < 0.001$) with the actual uptake of mEUD, with a correlation strength ranging between

TABLE 10
Demographic Profile of Respondents

| | Variable | Frequency | Percentage |
|---|---|---|---|
| Gender | Male | 116 | 56% |
| | Female | 93 | 44% |
| mEUD Experience | Yes | 32 | 15% |
| | No | 177 | 85% |
| IT background/ education | Yes | 117 | 56% |
| | No | 92 | 44% |
| Age Range | 18–25 | 193 | 92% |
| | 26–35 | 14 | 7% |
| | 36–50 | 2 | 1% |
| Mobile Device | Smart phone | 139 | 67% |
| | Smart phone and Tablet | 70 | 33% |
| Operating System | Android | 90 | 43% |
| | Apple (iOS) | 88 | 42% |
| | Android and Apple | 15 | 7% |
| | Other | 16 | 8% |

TABLE 11
Correlations between Model Constructs and Actual Uptake of mEUD (All Significant, $p < .001$)

| Construct | Actual uptake of mEUD |
|---|---|
| Self-efficacy | 0.368 |
| Expert support | 0.355 |
| Features / capabilities of mobile phone | 0.310 |
| Perceived fun | 0.284 |
| Social influence | 0.264 |
| Perceived benefits/advantages | 0.259 |
| Perceived ease of performing mEUD | 0.194 |
| IT background | No correlation |

$r = 0.194$ to $r = 0.368$, apart from IT background (Table 11). All correlations showed a positive relationship, which means an increase in one construct/factor is associated with an increase in mEUD activities (thus H1, H2, H3, H4, H5, H6, H7 supported). This suggests the possible contribution of these factors towards the uptake of mEUD by mobile users. Self-efficacy and expert support showed the strongest correlation, which means that respondents who have high self-efficacy and receive expert support are more likely to engage in mEUD activities than others. However, perceived benefits and perceived ease of performing mEUD showed the least correlation. Further analysis showed that perceived instrumental benefits were correlated positively with mEUD uptake ($p < 0.001$, $r = 0.256$, thus H1.1 supported), whilst perceived psychological benefits were not correlated with mEUD uptake ($p = 0.13$) (H1.2 not supported). However, mobile users rated psychological benefits (mean = 3.61, std = 0.88) as more influential on the actual mEUD uptake than instrumental benefits (mean = 3.34, std = 0.67). Differences were significant at the significance level $p = 0.001$, thus H1.3 is not supported.

No link between IT background and uptake of mEUD activities was found (thus H8 not supported). Therefore, people with IT background are not necessarily more engaged with mEUD activities.

To understand which of the above constructs truly predict the uptake of mEUD, we ran a multiple regression analysis using SPSS. Multiple regression analysis enables to predict the value of a dependent variable based on two or more predictors [47]. The regression analysis revealed that 20.60 percent of the variance in mEUD uptake can be accounted for by the above constructs. The model was statistically significant, $R^2 = .206$, $F(7, 201) = 7.46$, $p = 0.000$. However, self-efficacy and expert support were shown to have the strongest effect on actual uptake of mEUD.

Further correlation tests showed interesting positive associations between the constructs. Notably, perceived benefits are strongly correlated with perceived fun ($p < 0.001$, $r = 0.616$) signifying that users who perceive the advantages of mEUD find it more enjoyable to engage in such activities. Self-efficacy is positively correlated with the features of mobile devices ($p < 0.001$, $r = 0.618$), perceived ease of performing mEUD ($p < 0.001$, $r = 0.416$) and perceived fun ($p < 0.001$, $r = 0.495$), signifying that self-efficacy of users may be improved when mobile devices have the necessary features, and that users with high self-efficacy find mEUD easier to perform and more fun respectively. Social influence is also positively correlated with expert support ($p < 0.001$, $r = 0.402$), self-efficacy ($p < 0.001$, $r = 0.399$), and perceived benefits ($p < 0.001$, $r = 0.373$), signifying that people who receive expert advice, have high self-efficacy, or perceive the advantages of mEUD are more likely to be influenced by their social environment to perform mEUD. Expert support is positively correlated with features of mobile device ($p < 0.001$, $r = 0.467$) signifying that users with latest mobile device features may receive expert support from their service providers. Finally, features/capabilities of mobile devices strongly correlate with perceived fun ($p < 0.001$, $r = 0.471$), perceived ease of performing mEUD ($p < 0.001$, $r = 0.348$), and perceived benefits ($p < 0.001$, $r = 0.315$), signifying that features of mobile device enable users to perform a range of enjoyable mEUD activities, facilitate mEUD, and the development of apps that are beneficial.

Next, we divided our sample into two groups of users, users who do not perform mEUD and users who perform mEUD. Independent samples t-tests across all constructs of the model, were performed to compare the perceptions of these two groups toward mEUD.

T-tests showed that average rating of all constructs differed significantly between users with no mEUD experience and users with mEUD experience ($p < 0.01$), confirming our hypotheses (H1, H2, H3, H4, H5, H6, and H7). The average rating of users with mEUD experience was higher than users with no mEUD experience across all factors (Table 12). As anticipated, users who perform mEUD found mEUD activities easier to perform, and showed higher self-efficacy than users with no mEUD experience. Users with mEUD experience agreed that perceived fun and features of mobile device are equally important to uptake mEUD, whilst users with no mEUD experience placed more emphasis on perceived fun and perceived benefits. Users with mEUD experience rated features of mobile device and expert support highly as they allow them to develop complex applications. Expert support was not rated highly by users with no mEUD experience, emphasizing the need for expert support for those without experience.

TABLE 12
Average Rating of Model Constructs by Users without mEUD Experience and Users with mEUD Experience

| | Users with no mEUD experience | | Users with mEUD experience | |
|---|---|---|---|---|
| | mean | std | mean | std |
| Perceived ease of performing mEUD** | 3.47 | 0.69 | 3.94 | 0.74 |
| Perceived fun** | 3.26 | 0.89 | 3.84 | 0.83 |
| Perceived benefits** | 3.24 | 0.67 | 3.72 | 0.63 |
| Self-efficacy** | 3.15 | 1.04 | 3.91 | 0.92 |
| Features of mobile device** | 3.03 | 1.11 | 3.84 | 1.08 |
| Expert support** | 2.82 | 0.98 | 3.69 | 1.12 |
| Social influence** | 2.62 | 0.97 | 3.09 | 1.08 |

** *Statistical differences at $p = 0.01$.*

There was a consistent ranking of the importance of mEUD factors by users with no mEUD experience and users with mEUD experience, with little variation. Perceived ease of performing mEUD was perceived as the main factor for engaging in mEUD activities, followed by perceived fun and perceived benefits. Both groups of users agreed that social influence has little influence on their decision to uptake mEUD by mobile users, especially users with no mEUD experience.

We have run further t-tests to explore whether gender has an influence on the factors that impact mEUD uptake by mobile users. Indeed t-tests showed statistical differences ($p < 0.01$) between males and females in respect to the following factors: perceived benefits, perceived fun, self-efficacy, and features of mobile device. Males had higher self-efficacy (mean = 3.47), perceived mEUD as more rewarding (mean = 3.45), more fun (mean = 3.56), and believe they have the necessary mobile device features to perform mEUD than females (mean = 3.02, mean = 3.14, mean = 3.08 respectively). We claim that these differences are due mainly to gender since we have not shown any concepts or demos to our respondents that may have increased interest of either gender prior to completing the survey. However, both males and females had the same perception in regard to the ease of performing mEUD, expert support and social influence.

### 6.2 Focus Group

Finally, we have conducted a focus group with seven mobile users to explore any inconsistencies arising out of the testing survey and capture verbal evidence that supports the uptake factors of the model separately rather than as a whole. Moreover, this qualitative investigation was not conducted as a validation tool but rather a triangulation study to support and elaborate on the specific factors proposed by the model, checking their applicability in a different student population with a lower level of education (UG students). The focus group lasted for one hour, and discussions were audio-recorded. Participants were compensated with a £10 voucher each for their time.

All participants were second year and final year students at the University, and owned a smartphone; five were male and two were female. Six participants had conducted EUD activities, while the remaining participant had never performed such activities before. In terms of IT education, only one participant had a formal IT education. The age of the participants varied from 20 to 24 years. The discussions focused on the key constructs identified from the survey. In general participants referred to and relied on their past EUD experience, not always necessarily using a mobile device, to evidence how the model factors may influence mEUD uptake. Again, we applied thematic analysis to analyze the discussion transcripts.

According to our participants, perceived benefits/advantages of mEUD seems to be one of the driving forces behind EUD uptake; for example it helped a participant to complete his primary job: "*It was basically my manager who said to me "can you do this in Excel ?" and I was like "not really but I could have a try", so I went online, found out how to do it and the tutorial guy was saying, that did work. It was not on a mobile device, it was on a computer*" (Participant 3, EUD experience). Although not supported by the survey analysis, some participants emphasized the importance of psychological reward of EUD; for example: "*personally when I was making my App It was quite rewarding to feel that I achieved that considering that 6 months before I was telling myself I did not know how to code an App to that to have something effective and performing in the end*" (Participant 6, EUD experience).

Their second concern focused on the ease with which EUD can be achieved; for example: "*the ease of use is important, which is why Dreamweaver comes in first years so even though you were making a website, you were not writing HTML from scratch, you were designing it using point and click, using its user interface. What we managed to do is create a working solution that meets the requirements without knowing the technical skills behind it. That is definitely important*" (Participant 5, EUD experience).

Expert support was valued as a trusted resort in case of difficulty with EUD, for example: "*When I was doing it in RBS, basically what they had was a code development forum, groups of employees in RBS who really knew what they were doing. So any time I got stuck, I went to these people and ask for help*" (Participant 3, EUD experience).

Fun was perceived as a deciding factor that engages or inhibits users from EUD activities; for example: "*If you do not find it enjoyable you are going to give up quite easily. It is like when you are coding something personally and you have an error you can-not get through, you just click off that and just leave it*" (Participant 7, EUD experience). However, this may have no significant bearing on users who undertake EUD for only instrumental reasons; for example: "*I do not enjoy that. I have to do it. I do it for money making purposes as I am more of a graphic designer*" (Participant 1, EUD experience).

Self-efficacy as a motivating factor to undertake EUD was linked to knowledge and experience in software development; it improves with practice and induces end users to continue EUD uptake, for example: "*yeah. I think definitely when you have experience in it; you will probably carry on to do it. Like you might start your own project with other people, just to help people to develop something like application services for them to improve their processes*" (Participant 4, non EUD experience).

Social influence, however, was deemed to have a substantial impact on mEUD uptake only when coupled with EUD experience or knowledge; for example: "*depends how knowledgeable they are really, so if someone with a mobile, or a friend is very knowledgeable about End User Development and he*

*is basically telling me that it was better than traditional methods that I would be willing to give it a go and find out more about it. But I think it was somebody just a friend or family members who do not know a lot about it, would not influence me that much*" (Participant 5, EUD experience). This confirms the results of the survey where social influence received the lowest rating in respect to its importance.

Whilst participants recognized the latest advancements in mobile computing, they were concerned about the constraints imposed by, e.g., small screens, especially when the development necessitates handling the source code; for example: "*it may be very difficult to make tweaks to the code on a tablet or your mobile device whilst on a computer it might be quite good to notice the additions of the codes that you have made*" (Participant 6, EUD experience). EUD development approaches therefore have to accommodate the features and constraints of mobile devices; for instance: "*I think the current technology for end users is not developed, and you can hack it to be useful for development purposes but it is not easy. It is never going to be as easy as on the computer like it is much easier to just wait and do on a computer when you get home*" (Participant 1, EUD experience).

All participants agreed that EUD activities are generally partaken more by males than females mainly due to the 'geeky nature' of these activities, which females do not desire to be associated to; indeed subjective norms seem to decrease females' intention to engage in EUD activities, for instance: "*especially like, one of my friends is a girl, she did it for a bit and she was like 'I didn't like it'. She wasn't able to, just orally; she feels that she was the 'geek' in the company so she changes to marketing instead and says she don't want to be that*" (Participant 1, EUD experience).

## 7 Discussion of Findings

This exploratory research investigated and gathered evidence into the development activities of mobile applications by mobile users, providing a key understanding of the key factors that influence the uptake of mEUD. These factors are believed to directly influence the intention to perform mEUD activities, which in turn decides the actual level of uptake of mEUD activities.

### 7.1 Key Findings

The results of our studies enabled us to formulate a preliminary model for performing mobile end user development activities. The model stipulates seven key factors, which govern the intention of users to uptake EUD activities. Under each factor, we hypothesize relationships that predict the uptake of mEUD activities. Statistical analysis showed that these relationships differ in the degree of their effect on uptake of mEUD. The strength of these factors is represented by an arrow on the left hand side of Fig. 8, where the impact on user intention increases as we move towards the top.

The top three factors that dominantly influence mobile users' intention include: perceived ease of performing mEUD, perceived fun, and perceived benefits and advantages. These factors engage users and facilitate mEUD for non-technical users. However, self-efficacy and expert support seem to also be important factors for mEUD uptake.

We found that all seven factors correlated positively with the actual uptake of mEUD, with a varying degree of association. Some of these factors confirm results of a number of technology acceptance models, including: TAM [28] and UTAUT [31]. Moreover, there were positive correlations between certain factors such as: perceived benefits, perceived fun, self-efficacy, and features of mobile device.

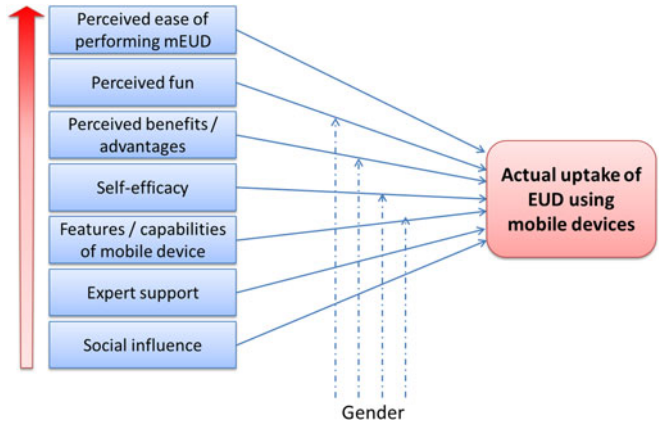


Fig. 8. Preliminary model depicting factors impacting mEUD (Strength of factors indicated on the left—factors with stronger impact are positioned higher).

*H1. Perceived benefits have a positive influence on the actual uptake of mEUD activities (**supported**).*
*H1.1. Perceived instrumental gains have a positive influence on the actual uptake of mEUD activities (**supported**).*
*H1.2. Perceived psychological gains have a positive influence on the actual uptake of mEUD activities (**not supported**).*
*H1.3. Perceived instrumental gains have a stronger influence on the actual uptake of mEUD activities than perceived psychological gains (**not supported**).*

Participants indicated that perceived benefits of mEUD play an important role in encouraging actual uptake of mEUD. In essence, activities that offer people benefits are perceived as useful and worth conducting. This is aligned with findings from the literature that perceived usefulness is essential to adopting new technologies [31]. We identified two types of gains: instrumental gains and psychological gains, which were shown to affect mEUD uptake. Instrumental gains refer to tangible gains and benefits that can be achieved through EUD activities. Examples of instrumental gains include generating revenue and creating business opportunities through the development of mobile apps. Psychological gains, however, refer to intangible (e.g., moral) gains and benefits. Examples of psychological gains include improving overall user experience and raising self-efficacy. Our results were inconclusive in regards to the effects of perceived instrumental and psychological benefits. The analysis showed that perceived psychological gains do not correlate with mEUD uptake, however users judged psychological gains as more decisive than instrumental gains in encouraging uptake of mEUD activities. This is probably a logical result unless the mobile user's primary job is the development of mobile apps.

*H2. Perceived ease of performing mEUD has a positive influence on the actual uptake of mEUD activities **(supported).*** Participants stressed the importance of perceived ease of performing mEUD to encourage users to uptake such activities. Indeed, this could be a deciding factor for two reasons.

First, mobile users have no technical expertise and are not willing to delve into coding activities. Second, they lack the confidence to perform activities outside their comfort zones. mEUD activities could be made more accessible by avoiding programming code and using direct manipulation (e.g., drag and drop) of the user interface and application logic. Numerous technology acceptance models emphasize the need to make new technologies easy to use in order to increase their adoption [28], [31].

*H3. Perceived fun has a positive influence on the actual uptake of mEUD activities* ***(supported)****.* An interesting factor that emerged from the discussions is the need to make mEUD activities *fun* and *enjoyable* to increase their uptake by mobile users. This is a relatively new construct, which has not been previously explored in the context of adopting new technologies [39]. The traditional approach of programming (i.e., writing code), although powerful, is considered boring in comparison to the less expressive visual approaches (i.e., drag and drop).

*H4. Rich features of the mobile device have a positive influence on the actual uptake mEUD activities* ***(supported)****.* Participants reported that features and technical capabilities of mobile devices encourage the uptake of mEUD activities. However, small screens, battery drainage, restricted memory capacity of mobile devices may hinder uptake. Indeed, physical specifications of the device (e.g., screen size) influence the type of interaction style that need to be used. For instance, it is impractical to ask users to write code on a small screen. Alternatively, it is more efficient if users can drag and drop visual elements. This agrees with the results of previous studies that facilitating conditions influence the adoption of new technologies [31].

*H5. Expert support has a positive influence on the actual uptake of mEUD activities (****supported****).* Participants emphasized the need for support in order to engage in mEUD activities. Participants may resort to this strategy as result of their lack of technical expertise and experience. Human support may come through two main channels: consultation with expert users and dedicated online platforms, and/or through direct contact with colleagues. The former channel is perceived as more credible and trustworthy, and is more likely to influence mobile users. Moreover, there is a third level of expert support, which originates from the mEUD tools themselves in the form of tutorials, walkthroughs, instructions, and immediate feedback during the development process.

*H6. Social support has a positive influence on the actual uptake of mEUD activities (****supported****).* The construct of social environment has been demonstrated to be relevant to the adoption of new technologies [31], [34]. This is also supported in our research. Friends and relatives do have some influence on mEUD uptake, although with a lesser degree than the rest of the factors.

*H7. Mobile users with high self-efficacy are more likely to uptake mEUD activities than those with low self-efficacy* (**supported**). Users with higher self-efficacy level are likely to perform better than those with lower self-efficacy, and thus engage more in mEUD activities. This is an intrinsic characteristic and precondition, which influences the uptake of mEUD activities. The effect of self-efficacy is not discussed explicitly in other technology acceptance models such as TAM [28] and UTAUT [31], although it has been shown that self-efficacy beliefs affect human motivation, learning and performance [15].

*H8. Technical background has a positive influence on the actual uptake of mEUD (****not supported****).* We hypothesized that mobile users were inhibited from conducting mobile end user development activities as a result of their non-technical education. However, our analysis showed there is no link between IT background and uptake of mEUD activities. Therefore, acquiring an IT education does not necessarily mean engaging in software development activities.

Gender was found to have a moderating effect on the impact of perceived fun, perceived benefits, self-efficacy, and features of mobile devices. This confirms previous findings such as [11], [31]. Some insights from the focus group study supported the claim that females are less likely to engage in mEUD activities as a result of its social negative connotation. However, further research is still required to investigate whether the use of tools and scenarios that are linked to females' interests would raise their uptake of such activities.

Evidently, mEUD creates new personal and business opportunities for both IT experts and end user developers. However, there exists a limitation to what can be achieved using mobile devices, primarily as a result of mobile hardware limitations, such as screen size and interaction style. This makes coding or scripting on small screen devices impractical and very challenging. Whilst mEUD can use a simple click and select interaction style on mobile devices to develop simple apps, which encompass various services, it requires a dedicated visual language or new interaction paradigm to enable the implementation of complex behaviors using, for example, conditions (e.g., if then else) and loops/iterations within mobile apps.

### 7.2 Limitations of This Research

One of the limitations of this research is the low number of participants who have actual mEUD experience. mEUD activities are still uncommon amongst mobile users despite the rapid advancements in mobile devices. To tackle this issue, we used Internet EUD forums to attract representative end users. However, this was still challenging due to the regulations imposed by forums' administrators.

Moreover, our participants were mainly drawn from a student population. This population matches in principle our target group of mobile technology users who are not necessarily educated programmers. However, the student perceptions, motivations and expectations of mEUD may be different from the general population. The proposed model and theoretical implications, therefore, may not be generalizable and are yet to be investigated and confirmed with non-student samples.

We have explored mEUD practices and activities by end user developers and IT experts based on their experience of using various EUD tools. There was less focus on text-based mEUD tools and complex constructs by our participants despite their potential advantages maybe because of their lack of experience. In addition, the showing of a video example for the first focus group may be a biasing factor, although we have taken measures to reduce the potential bias by asking each participant to state other examples of mEUD which they have experienced or know of.

In summary, the generalization of our model should be done with caution since different factors might influence different mEUD tools and contexts. It is worth mentioning here that there may be other confounding or external factors not included in the model above, such as personal interests that may have contributed to the degree of uptake of mEUD by our participants. Indeed, this research did not investigate the effect of personality characteristics and traits on design decision making when performing mEUD activities, nor it did explore the effect of perceived risks, for instance losing personal data and locking mobile devices, on the actual mEUD uptake.

Finally, the proposed preliminary theoretical model for the uptake of mEUD activities has not been tested thoroughly. The contribution of each factor towards actual mEUD uptake is still tentative and requires further research. Therefore, some of the proposed influencing factors might not be just as significantly important or additional factors (e.g., intrinsic motivation and perceived risks) might need to be considered.

## 8 The Way Forward for mEUD

This paper reports on the first steps in investigating what motivates and hinders the use of mobile devices by non-programmers to perform complicated operations which amount to software development activities (mEUD). An exploratory approach was followed to uncover existing mEUD practices, factors, attitudes and mental models. This approach comprises an initial survey, a focus group study, and a testing study. Our findings underpin a preliminary theoretical model of mEUD linking the key enablers of end user development using mobile devices, and giving rise to seven research hypotheses attempting to explain relationships between factors of the model and mEUD uptake. In particular, the following factors were identified: perceived benefits, perceived ease of performing, perceived fun, features of mobile device, expert support, social support, and self-efficacy. We hypothesize that these seven factors influence user intention to perform end user development using mobile devices.

The results of the work reported here raise some implications for the way mEUD activities can be supported:

(a) Both social and expert support are important for encouraging mEUD and guiding end users to successful results (H5 and H6);
(b) mEUD tasks should be carefully designed to maximize ease-of-use using mobile interaction features (H2 and H4);
(c) Motivation for performing mEUD comes from perceived usefulness of activities but also from the perceived fun when performing these activities (H1 and H3);
(d) Certain groups of users are more likely to engage in mEUD, and effort should be made to reach to the other types of users when mEUD by these groups is also desired (H7 and the moderating effect of gender).

These implications should be taken into account when deriving requirements for mEUD tools and developing mEUD support approaches and methodologies. We are currently conducting the next phase of mEUD research by testing the impact of these conclusions for the way we develop mEUD support tools, by conducting a comparative experimental study to assess how they would enhance mEUD uptake and the quality of resulting apps. One interesting aspect that we aim to explore in the future is the promising domains of mEUD for different groups of mobile users. We are also using our findings to develop a mobile version of our service composition tool [49].

## Acknowledgments

The authors wish to thank the participants who took part in our studies. We also extend our thanks to the reviewers of this paper for their useful comments and feedback. This research is partly funded by Manchester Business School.

## References

[1] M. McCabe. (2013). Ownership of smartphones soaring, global study shows [Online]. Availabe: http://goo.gl/Q3KwYs.
[2] J. Nielsen. (2013). How the mobile consumer connects around the globe [Online]. Available: http://goo.gl/mM9HJM.
[3] N. Zang, M. B. Rosson, and V. Nasser, "Mashups: Who? What? Why?" in *Proc. Extended Abstracts Human Factors Comput. Syst.*, New York, NY, USA, 2008, pp. 3171–3176.
[4] L. Grammel and M. A. Storey, "An end user perspective on mashup makers," Tech. Rep. DCS-324-IR, University of Victoria, Victoria, BC, Canada, 2008.
[5] H. Lieberman, F. Paterno, M. Klann, and V. Wulf, "End-user development: An emerging paradigm," in *End User Development* (Human-Computer Interaction Ser.), vol. 9, H. Lieberman, F. Paterno, and V. Wulf, Eds. New York, NY, USA: Springer-Verlag, 2006, pp. 1–8.
[6] A. Sutcliffe and N. Mehandjiev, "End user development," *Commun. ACM*, vol. 47, no. 9, pp. 31–32, 2004.
[7] N. Mehandjiev, A. Sutcliffe, and D. Lee, "Organisational view of end-user development," in *End User Development* (Human-Computer Interaction Ser.), vol. 9, H. Lieberman, F. Paterno, and V. Wulf, Eds. New York, NY, USA: Springer-Verlag, 2006, pp. 371–399.
[8] A. Namoun, T. Nestler, and A. De Angeli, "Service composition for non-programmers: prospects, problems, and design recommendations," in *Proc. IEEE Eur. Conf. Web Services*, Washington, DC, USA, 2010, pp. 123–130.
[9] N. Mehandjiev, A. Namoun, U. Wajid, L. Macaulay, and A. Sutcliffe, "End user service composition—Perceptions and requirements" in *Proc. IEEE Eur. Conf. Web Services*, Washington, DC, USA, 2010, pp. 139–146.
[10] J. Rode, M. B. Rosson, and M. A. Pérez-Quiñones, "End user development of web applications," in *End User Development* (Human-Computer Interaction Ser.), vol. 9, H. Lieberman, F. Paterno, and V. Wulf, Eds. New York, NY, USA: Springer-Verlag, 2006, pp. 161–182.
[11] L. Beckwith, C. Kissinger, M. Burnett, S. Wiedenbeck, J. Lawrance, A. Blackwell, and C. Cook, "Tinkering and gender in end-user programmers' debugging," in *Proc. SIGCHI Conf. Human Factors Comput. Syst.*, New York, NY, USA, 2006, pp. 231–240.
[12] J. Cao, Y. Riche, S. Wiedenbeck, M. Burnett, and V. Grigoreanu, "End-user mashup programming: Through the design lens" in *Proc. SIGCHI Conf. Human Factors Comput. Syst.*, New York, NY, USA, 2010, pp. 1009–1018.
[13] J. Pane, B. Myers, and C. Ratanamahatana, "Studying the language and structure in non-programmers' solutions to programming problems," *Int. J. Human Comput. Studies*, vol. 54, no. 2, pp. 237–264, 2001.
[14] C. Ardito, M. F. Costabile, G. Desolda, R. Lanzilotti, M. Matera, A. Piccinno, and M. Picozzi, "User-driven visual composition of service-based interactive spaces," *J. Visual Lang. Comput.*, vol. 25, no. 4, pp. 278–296, 2014.
[15] A. Bandura, N. E. Adams, A. B. Hardy, and G. N. Howells, "Tests of the generality of self-efficacy theory," *Cognitive Therapy Res.*, vol. 4, no. 1, pp. 39–66, 1980.
[16] Y. Deshpande and S. Hansen, "Web engineering: Creating a discipline among disciplines," *IEEE MultiMedia*, vol. 8, no. 2, pp. 82–87, 2001.

[17] A. Repenning and A. Ioannidou, "What makes end-user development tick? 13 Design guidelines," *in End User Development* (Human-Computer Interaction Ser.), vol. 9, H. Lieberman, F. Paterno, and V. Wulf, Eds. New York, NY, USA: Springer-Verlag, 2006, pp. 51–85.
[18] A. J. Ko, R. Abraham, L. Beckwith, A. Blackwell, M. Burnett, M. Erwig, C. Scaffidi, J. Lawrance, H. Lieberman, B. Myers, M. B. Rosson, G. Rothermel, M. Shaw, and S. Wiedenbeck, "The state of the art in end-user software engineering,," *ACM Comput. Surv.*, vol. 43, no. 3, pp. 1–44, 2011.
[19] N. Mehandjiev, A. Namoun, F. Lécué, U. Wajid, and G. Kleanthous, "End users developing mashups," in *Web Services Foundations*. New York, NY, USA: Springer-Verlag, 2014, pp. 709–736.
[20] N. Mehandjiev, T. Stoitsev, O. Grebner, S. Scheidl, and U. Riss, "End user development for task management: Survey of attitudes and practices," in *Proc IEEE Symp. Visual Lang. Human-Centric Comput.*, Herrsching am Ammersee, Germany, 2008, pp. 166–174.
[21] S. Cuccurullo, R. Francese, M. Risi, and G. Tortora, "MicroApps development on mobile phones" in *Proc. 3rd Int. Symp. End-User Develop.*, Torre Canne, Italy, 2011, pp. 289–294.
[22] J. Danado and F. Paterno, "Puzzle: A visual-based environment for end user development in touch-based mobile phones," in *Proc. Int. Conf. Human-Centered Softw. Eng.*, Toulouse, France, 2012, pp. 199–216.
[23] J. Seifert, B. Pfleging, E. C. V. Bahamondez, M. Hermes, E. Rukzio, and A. Schmidt, "Mobidev: A tool for creating apps on mobile phones," in *Proc. ACM Int. Conf. Human Comput. Interaction With Mobile Devices Services*, Stockholm, Sweden, 2011, pp. 109–112.
[24] J. Danado, M. Davies, P. Ricca, and A. Fensel, "An authoring tool for user generated mobile services" in *Proc. ACM 3rd Future Internet Conf. Future Internet*, Berlin, Germany, 2010, pp. 118–127.
[25] C. Cappiello, M. Matera, M. Picozzi, A. Caio, and M. T. Guevara, "MobiMash: End user development for mobile mashups" in *Proc. ACM Int. Conf. World Wide Web*, Lyon, France, 2012, pp. 473–474.
[26] W. Slany, "A mobile visual programming system for Android smartphones and tablets," in *Proc. IEEE Symp. Visual Lang. Human-Centric Comput.*, 2012, pp. 265–266.
[27] E. M. Rogers, *Diffusion of Innovations*, 4th ed. New York, NY, USA: Free Press, 1995.
[28] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS Quart.*, vol. 13, pp. 319–340, 1989.
[29] I. Ajzen, "The theory of planned behaviour," *Org. Behavior Human Decision Processes*, vol. 50, no. 2, pp. 179–211, 1991.
[30] M. Fishbein and I. Ajzen, *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research*. Reading, MA, USA: Addison-Wesley, 1975.
[31] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User acceptance of information technology: Toward a unified view," *MIS Quart.*, vol. 27, no. 3, pp. 425–478, 2003.
[32] J. H. Wu, S. C. Wang, and L. M. Lin, "Mobile computing acceptance factors in the healthcare industry: A structural equation model," *Int. J. Med. Informat.*, vol. 76, no. 1, pp. 66–77, 2007.
[33] S. H. Hung, C. M. Chang, and S. R. Kuo, "User acceptance of mobile e-government services: An empirical study," *Government Inform. Quart.*, vol. 30, no. 1, pp. 33–44, 2013.
[34] C. S. Yu, "Factors affecting individuals to adopt mobile banking: Empirical evidence from the UTAUT model," *J. Electron. Commerce Res.*, vol. 13, pp. 104–121, 2012.
[35] Y. S. Wang, M. C. Wu, and H. Y. Wang, "Investigating the determinants and age and gender differences in the acceptance of mobile learning," *Brit. J. Edu. Technol.*, vol. 40, no. 1, pp. 92–118, 2009.
[36] K. Yang, "Determinants of US consumer mobile shopping services adoption: implications for designing mobile shopping services," *J. Consum. Marketing*, vol. 27, no. 3, pp. 262–270, 2010.
[37] T. Zhou, "Understanding mobile Internet continuance usage from the perspectives of UTAUT and flow," *Inform. Develop.*, vol. 27, no. 3, pp. 207–218, 2013.
[38] S. Moghavvemi, N. A. M. Salleh, W. Zhao, and M. Mattila, "The entrepreneur's perception on information technology innovation adoption: An empirical analysis of the role of precipitating events on usage behaviour," *Innovation, Manage., Policy Practice*, vol. 14, no. 2, pp. 231–246, 2012.
[39] T. Zhou, "Examining location-based services usage from the perspectives of UTAUT and privacy risk," *J. Electron. Commerce Res.*, vol. 13, pp. 135–144, 2012.
[40] J. C. Greene, V. J. Caracelli, and W. F. Graham, "Toward a conceptual frame-work for mixed-method evaluation designs," *Edu. Eval. Policy Anal.*, vol. 11, pp. 255–274, 1989.
[41] J. Bethlehem, *Applied Survey Methods: A Statistical Perspective*. Hoboken, NJ, USA: Wiley, 2009.
[42] D. Morgan, *Focus Groups as Qualitative Research*, 2nd ed. Newbury Park, CA, USA: Sage, 1997.
[43] C. Cassell and G. Symon, *Essential Guide to Qualitative Methods in Organizational Research*. London, U.K.: Sage, 2004.
[44] Anonymous. (2013). App Cat [Online]. Available: http://www.app.cat/.
[45] D. R. Compeau and C. A. Higgins, "Computer self-efficacy: Development of a measure and initial test," *MIS Quart.*, vol. 19, no. 2, pp. 189–211, 1995.
[46] E. Babbie, *The Practice of Social Research*, 9th ed. Belmont, CA, USA: Wadsworth, 2001.
[47] S. Chatterjee and A. S. Hadi, *Regression Analysis by Example*, 5th ed. Hoboken, NJ, USA: Wiley-Blackwell, 2012.
[48] B. Athreya, F. Bahmani, A. Diede, and C. Scaffidi, "End-user programmers on the loose: A study of programming on the phone for the phone," in *Proc. IEEE Symp. Visual Lang. Human-Centric Comput.*, 2012, pp. 75–82.
[49] N. Mehandjiev, L. Ning, and A. Namoun, "Assisted composition of services on mobile devices," in *End-User Development*. New York, NY, USA: Springer-Verlag, 2015, pp. 242–248.
[50] K. Charmaz, *Grounded Theory: A Practical Guide Through Qualitative Analysis*. Thousand Oaks, CA, USA: Sage, 2006.

**Abdallah Namoun** received the Bachelor's degree in computer science and the PhD degree in informatics both from the University of Manchester, Manchester, U.K. He is currently an assistant professor of Interactive Information Systems at the Faculty of Computer and Information Systems, Islamic University of Madinah, Medina, Saudi Arabia. He investigates user needs and interaction with technology, acceptance and adoption of innovative technologies, design of effective visual interfaces, and methods for testing usability of human interfaces.

**Athanasia Daskalopoulou** is currently working toward the PhD degree in marketing at Manchester Business School, Manchester, U.K. She investigates consumers' experiences with products, services, and interfaces. Her research interest includes the exploration of cross-disciplinary design approaches.

**Nikolay Mehandjiev** studies the interface between intelligent service-based systems and people, aiming to ensure that complex information technology can be used and controlled by users who are not computer scientists with Service Systems Group, The University of Manchester, Manchester, U.K. His current research interest includes the uptake of mobile platforms for software applications with sophisticated functionality, investigating the factors which can make such tools accepted and used by the general public. He has published in, and reviewed for a number of international journals and specialist conferences. He is a member of the IEEE.

**Zhang Xun** received the Bachelor's degree in information technology management for business from the University of Manchester, Manchester, U.K., in 2014. She investigates user adoption of mobile computing and end user development. She is currently working toward IT consulting in Singapore.