Making Space for All: Ensuring Gender Equity in Educational Makerspaces

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ABSTRACT: This paper examines the relationship between gender and making within an educational context, a topic which is not thoroughly addressed in existing empirical studies. By reviewing literature from these two distinct fields it answers the research question: What factors are identified in the research as influencing gender equity in educational makerspaces? The conceptual framework for educational makerspaces guides an examination of themes in current literature. The people who use the space, the activities that occur there and the means that are available are interconnected aspects which can all have an impact on gender equity. The Self-determination Theory in relation to makerspace continuance outlines the basic psychological needs that must be met in order for a user to be intrinsically motivated to continue using a makerspace. Finally, recommendations are made for future research regarding barriers to participation, the use of e-textiles and design of the physical environment.

RÉSUMÉ: Cet article examine la relation entre le genre d'une personne et la fabrication dans un contexte éducatif, un sujet qui n'est pas traité de manière approfondie dans les études empiriques existantes. En examinant la littérature de ces deux domaines distincts, nous répondons à la question de recherche suivante: Quels facteurs sont identifiés dans la recherche comme influençant l'équité entre les sexes dans les espaces de formation des enseignants? Le cadre conceptuel des espaces de formation pédagogique a guidé la recension des écrits. Les personnes qui utilisent l'espace, les activités qui s'y déroulent et les moyens disponibles sont des aspects interconnectés qui peuvent tous avoir un impact sur l'équité des sexes. La théorie de l'autodétermination en relation avec la persistance du 'makerspace' décrit les besoins psychologiques de base qui doivent être satisfaits pour qu'un utilisateur soit intrinsèquement motivé à continuer à l'utiliser. Finalement, des recommandations sont faites pour de futures recherches concernant les obstacles à la participation, l'utilisation des textiles électroniques et la conception de l'environnement physique.

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Many schools across North America are establishing spaces for hands-on activities where students can have access to a variety of tools and technology for creating digital or physical prototypes or tangible products of their learning (Hughes, 2017; Johnson, Adams-Becker, Estrada & Freeman, 2015). As these makerspaces are becoming more common in our schools, it is preferable to consider how these spaces can be designed and built with equity in mind, rather than having to make costly or time-consuming changes after they are operational. Research into gender and how it relates to learning and technology can help inform policies and practices to ensure equitable access to these spaces so that students and teachers alike are apt to enjoy the benefits of using these unique learning environments.

Purpose

The purpose of this paper is to examine the relationship between gender and makerspaces, as it pertains to education. By reviewing current literature, this paper will answer the question: What factors are identified in the research as influencing gender equity in educational makerspaces? In the absence of significant research on gender in relation to making, this paper reviews empirical studies from these separate fields to establish a baseline for some initial understanding and for further research.

The paper begins with a discussion of the current gender gap in community makerspaces and a rationale for why gender equity should be an important consideration. Next, the conceptual framework for educational makerspaces proposed by Hira, Hynes and Szalay (2018) is presented. It is used to guide an examination of the current research as it relates to the people, activities and means that can impact gender equity in educational makerspaces.

For the purposes of this paper, the term educational makerspace will be used to refer to any hackerspace, FabLab, learning commons, or other such space in a school where students and teachers have access to digital fabrication tools and a means to share their learning. The topic of gender is a complicated one, as some students in our schools do not fit into the traditional binary categories of gender. As the scope of this paper does not allow for a thorough examination of the concept of gender, for the purposes of answering the research question, following the example of Holbert (2016), the terms female, girl and woman will be used to describe anyone who self-identifies with this gender.

Makerspaces and Gender: History and Background

The recent trend of makerspaces in formal educational contexts was preceded by the emergence of the maker movement in a much broader context at the beginning of the 21st century. In these relatively new community-based makerspaces there is a pronounced gender gap. Holbert (2016) observes that they are heavily dominated by men, while Faulkner (2014) refers to female users of a makerspace as "novelties". This observation is further supported by data from a maker market study that shows over 8 in 10 makers are male, with an average income of $106,000 (Make/Intel, 2012). This, in turn, aligns with the portrait provided by Kafai, Fields and Searle (2014) of "typically white, affluent males" (p. 551) as well as their discussion of "historically marginalized groups - particularly girls and women" (p. 551). The women who do use community makerspaces face the same challenges as men with regards to financing projects, finding information and accessing tools or supplies (Intel/Harris, 2014), but they face the additional challenges of having to arrange for child care (Faulkner, 2014) and a lack of mentorship (Intel/Harris, 2014). Females are more likely than males to come to a makerspace with a background in arts, crafting and design (Intel/Harris, 2014) and, consequently, many women report that "their work styles are undervalued or just misunderstood" (Faulkner & McClard, 2014, p. 191). These statistics bring to light a maker culture that is monopolized by men and makerspaces that some women find unwelcoming.

In contrast to users of community makerspaces, students and teachers wishing to use educational makerspaces do not typically face many of these same barriers, as there is no cost to users, and information, tools and materials are supplied by the school system. The question of gender equity, however, remains an important topic of discussion, seen in the work of Kafai et al., (2014) who argue that "discussions around the gendering of technology are important because they bring preconceived notions related to gender out into the open, even if they are not completely reconciled" (p. 549).

In addition, research related to interest in technology and STEM reveals a unique opportunity for educational makerspaces with regards to gender equity. Cai, Fan and Du (2017) found that despite being surrounded by technology in their daily lives, "females still have [a] less positive attitude toward technology use in general"

(p. 10) and Allegrini (2015) reminds us that "women continue to be the largest under-represented group in STEM" (p. 43). However, this gender gap does not exist from childhood. In terms of attitude towards technology, the gap begins to widen at age 14 (Ardies, De Maeyer, & Gijbels, 2014) while interest in STEM diminishes for both genders over the course of their high school education, but more noticeably for girls (Sadler, Sonnert, Hazari & Tai, 2012). This may mean that well designed learning experiences in educational makerspaces can still impact interest levels, future career paths and opportunities when they happen during elementary grades or the first few years of secondary school.

The issue of gender equity in educational makerspaces, then, can potentially impact gender equity in other aspects of society. Bean, Farmer and Kerr (2015) suggest that making can lead to success for women in the worlds of innovation and entrepreneurship. A report from Intel/Harris (2012) offers that involvement in maker and STEM activities "can help females develop skills and improve their earning potential" (p. 7). Furthermore, Wajcman (2010) asserts that it is "imperative that women are involved throughout the processes and practices of technological innovation" (p. 152) and goes on to advocate that

> it is not only an equal employment opportunity issue, but is also crucially about how the world we live in is shaped, and for whom. We live in a technological culture, a society that is constituted by science and technology, and so the politics of technology is integral to the renegotiation of gender power relations. (p. 152)

Thus, striving for gender equity in educational makerspaces may have positive implications for the role that women play in the worlds of STEM, entrepreneurship, design and innovation.

Although there are many studies on making, educational technology, and women in STEM, there are still "relatively few studies on Making in formal school contexts" (Chu, Angello, Saenz & Quek, 2017, p. 39). Further to that, Smith, Iversen and Veerasawmy (2016) identify the need for research into teacher training programs that support maker activities so that teachers are equipped with the skills and pedagogy needed to get the most out of makerspaces. However, perhaps most pertinent to this paper, are the findings of Papavlasopoulou, Giannakos and Jaccheri (2017) who did a literature review of the maker movement. They were surprised that very few empirical studies looked at gender andmaking and commented that they "expected more studies to

provide insights on how making activities benefit females specifically, as the main subject areas applied are STEM and programming" (p. 62). The largely male-dominated culture of community-based makerspaces, combined with a lack of research on gender and making, suggests that there is both a moral obligation and an opportunity for educators as we incorporate making into formal education.

Makerspace Framework for Equity

To guide the discussion of equity and to organize a review of current literature into themes, the conceptual framework for educational makerspaces proposed by Hira, Hynes and Szalay (2018) will be used. They posit that the purpose of a makerspace is directly related to the people (those who use the space), the means (the tools, technology and materials that are available in the space) and the activities (testing, prototyping, teaching that occur there); moreover, each of these three aspects are interrelated. For example, certain users may be attracted to the space by particular tools that are available or by activities and workshops that are occurring. In the same way, the activities may be limited or enhanced by the tools that are available, or by the skills and interests of the teachers, students and community members who use the space. While purpose can be established before the makerspace is created, it can also evolve over time to meet changing needs of the users, new technology or changing curriculum or projects.

Hira et al., (2018) note that in the past, the purpose of most educational makerspaces has been focused on the aspect of activities. However, they also document the need for equity and explain that these concerns can be addressed when the purpose is more focused on the aspect of people. Hughes (2017) calls on educators to work for equity by focusing on users, remarking that "given the opportunities that a makerspace affords its participants, it is critical to bring the opportunities and experiences to all students, including those often left out because of economic and social inequalities" (p. 103). Martin (2015) also recognizes the opportunity that educational makerspaces afford, claiming that "bringing making into school settings has the potential to bring [...] making to a wider and more diverse audience than ever before" (p. 37). It follows, then, that the purpose of an educational makerspace should be to ensure that all of its users have equitable access to the benefits of making and that the focus of the space should be on

meeting the needs of its users.

People

When equitable access is made explicit in the purpose of the makerspace and the focus is on the people who use it, two theories emerge in the literature that can inform the discussion of achieving equity: the Gender Similarities Hypothesis and Self-determination Theory in relation to makerspace continuance.

After reviewing several meta-analyses on psychological gender differences, Hyde (2016) concluded that the data contradicts existing gender stereotypes, and that there is no appreciable difference in mathematics or verbal skills between males and females. This led her to develop the Gender Similarities Hypothesis which states that males and females are similar on most psychological variables. Reilly (2012) agrees with this, showing that any observed gender differences in cognitive abilities are actually mediated by gender inequalities in the culture. In addition to math and literacy, gender has also been shown to have no effect on creative thinking abilities (Noh, 2017). Thus, if gender does not account for a difference in ability, the discussion of equity can shift away from a gender gap in innate ability and move towards other factors that influence who chooses to use educational makerspaces.

In an educational setting, makerspaces can be used by teachers, students, community members and, possibly, parents, either as a part of regular classroom instruction or as participants in extra-curricular activities or clubs. Inequitable use can occur during extra-curricular opportunities, as participation in these activities is voluntary for students; however, when they are used for curriculum based activities, all students in a given class would be required to use the space. In mandatory structured learning activities, students must be physically present but can still choose whether they will continue to be engaged in what they are doing, or simply go through the motions of completing activities. In order to understand makerspace continuance - a user's intention to continue to engage in activities in a makerspace - Han, Yoo, Zo and Ciganek (2017) examine how meeting a user's basic psychological needs is related to intrinsic motivation. Their study is based on the Self-determination Theory (SDT) and the Basic Psychological Needs Theory (BPNT). They found that continuance intention is positively related to intrinsic motivation, which is increased when the basic psychological needs of autonomy, competence and relatedness (or

social connectedness) are met, and argue that environmental support (technical, economic and social) in a makerspace can help meet these needs of the user. These will be discussed in more detail, and in relation to gender, within the relevant aspects of the framework below.

Students

Although there may not be cognitive differences in the abilities of our male and female students, there are studies that highlight other differences that are related to gender. Understanding these differences can help to ensure that our students are equally engaged in educational makerspaces.

When studying attitudes towards technology use, Cai, et al. (2017) found that boys showed a stronger belief in the societal usefulness of technology and in their own confidence to use it effectively. This means that it is not so much that girls do not like using technology, it is more that they do not see the point and may not be confident in using it. This relates to all three of the needs required to increase makerspace continuance. If girls do not feel confident, their need for competence may not be met, and they will have reduced autonomy when working on projects. Failing to believe in the societal importance may also impact social connectedness. These needs must be considered when planning activities for users.

Another gendered difference is the impact of teacher expectations. Vekiri (2010) found that the technology self-efficacy of girls (or confidence in their ability) was affected more significantly than boys by the beliefs and expectations that teachers had of their students. This highlights the role that teachers can play in meeting the psychological needs of female users of educational makerspaces.

Teachers

As teachers are not obliged to use a makerspace to teach their students, it is important to examine equitable use by teachers, and discuss factors that could lead them to choose making as a pedagogical approach. As teachers are often what Kurti, Kurti and Fleming (2014) refer to as "spacemakers" or leaders in the establishment and operation of a makerspace, we must also discuss the role that they can play in working towards equity for their students.

Teo (2014) measured teachers' acceptance of technology and found it to be a predictor of actual use. From this study, it was confirmed that five factors affecting teacher acceptance are perceived ease of use, perceived usefulness, attitude towards technology, social norms, and facilitating conditions. Teo suggests that technology training for teachers should address these five factors in order to be effective in translating to actual use after the training session. He also observed that male teachers rated themselves higher than females with regards to perceived ease of use, but found that the effect size was small on overall acceptance. Perceived ease of use is here linked to the idea of competence, which is one of the basic psychological needs of a teacher that must be met if he or she is going to continue to use a makerspace. During training sessions, care should be taken not to make technology seem unnecessarily complicated, as this could impact its acceptance for both male and female teachers.

Cohen, Huprich, Jones and Smith (2017) document stumbling blocks for teachers wishing to make use of makerspaces, citing teacher concern about "peer and administrator support as well as lack of resources" (p. 430). These reflect the social norms and facilitating conditions studied by Teo (2014) and can be addressed by the social and financial support recommended by Han et al., (2017).

In a summary of findings of their empirical studies, the need for training teachers in the use of makerspaces is further noted by Eriksson, Heath, Ljungstrand and Parnes (2018). One might reasonably conclude that this training would lead to increased autonomy and competence for teachers, which would, in turn, increase their makerspace continuance. Recommendations for this training include giving teachers the opportunity to use the makerspace with colleagues prior to using it with students (Petrich, Wilkinson & Bevan, 2013), and providing a series of sessions rather than a single workshop (Cohen et al., 2017). Bean, Farmer and Kerr (2015) used a qualitative focus group methodology to examine "variables that contribute to the participation and retention of women in Makerspaces" (p. 63) and found that child care concerns were a common barrier to participation for female makers in the community. With that in mind, when teacher training is offered during regular work hours, child care concerns would not limit the participation of women, as they do for female makers in the community (Bean, Farmer & Kerr, 2015). Such proactive measures are, by extension, impactful on student learning for when teachers

are adequately supported and sufficiently trained they are poised to influence the other users of the makerspace.

In studying student attitudes toward technology, Ardies et al. (2014) discovered that teachers can have a small but significant impact on "beliefs about gender differences, perceived difficulty of technology and boredom" (p. 62) of their students. Additionally, they reported that teachers can have an even larger impact on their students with regards to the usefulness or "consequences of technology, ambitions for a technological career, and interest in technology" (p. 62). All of this is very encouraging as it points to the fact that teachers can influence how students perceive the relationship between gender and technology use. By ensuring that female students are given ample opportunity to both explore and enable their use of technology, teachers are able to encourage students to give thought to future career paths that may not have been considered otherwise.

While a teacher's need for social support was mentioned earlier, it is also important to note the social support that they can offer to students. Han et al. (2017) found that social support can positively impact intrinsic motivation and the desire to continue using a makerspace. Examples of this social support could include highlighting the accomplishments of students, which would meet the need of competence, and encouraging collaboration, which would meet the need of relatedness.

Mentors

Community members and parents are another group of users who have the potential to positively influence equity in an educational makerspace, especially when they act as mentors for students. The report by Intel/Harris (2014) states that for female makers, next to lack of financial means, "lack of mentorship is the second-ranked challenge with one in three women citing it as a barrier to making" (p. 8). A mentor who is willing to invest time in an educational makerspace could provide the technical and social support that is needed to help meet a student's need for autonomy, competence and relatedness, by explicitly teaching skills, coaching them to believe in their ideas, or collaborating on projects. After reviewing 12 years of literature on interest, motivation and attitude towards science and technology (S&T), Potvin and Hasni (2014) found support for the efficacy of role models, especially female role models for female students, who can help increase "interest in S&T careers [197],

even in male-dominated fields, like technology" (p. 106).

Cultural and societal norms. People of course cannot be separated from the cultural and societal norms that surround them, so these must also be considered in an educational makerspace. The Intel/Harris report (2014) states that one in six female makers surveyed comes from a culture that finds making inappropriate for women. While this may seem like a daunting challenge to address, Holbert (2016) suggests that we "reframe how and why we make to acknowledge and elevate the values and goals of the communities we hope to engage" (p. 38). Another approach offered by Vossoughi, Hooper and Escudé (2016) is to "shift the discourse away from deficit orientations" (p. 219). Rather than asking ourselves why females aren't engaging in maker activities, educators can look to identify how girls are currently making and use this as a starting point for working towards gender equity. Vossoughi et al. (2016) observe that educational programs often create maker activities and spaces that appear to be neutral but are in fact based on the dominant cultures and norms in society, then strive for equity with efforts to attract a more diverse group of participants. They suggest that this approach is ineffective and that educational makerspaces need to consider "the critical examination and potential reorganization of the activities and pedagogies themselves" (p. 214).

Activities

The people aspect of an educational makerspace is directly and closely linked to its purpose of ensuring equitable access for all users, but this cannot be realized without carefully considered activities. Current research recommends basing activities on learners' interests, framing them in reality and starting from a place of familiarity. For example, Erikson et al. (2018) advocate for inclusive activities, explaining that digital fabrication should not be intriguing for only the students who have an interest in computing, but instead needs to draw on the diverse interests of students in order to "foster technological literacy" (p. 14). Similarly, in a study of 301 middle school information science students, Vekiri (2010) noted a greater interest in computing related tasks, when activities were student centred and personally meaningful. If learning is to be student centred, then teachers must provide elements of choice. Han et al. (2017) suggest that choice increases feelings of autonomy, one of the basic needs that must be met for makerspace continuance.

In examining cultural values and their connection to diversity in maker activities, Holbert (2016) strongly advocates for activity framing, stating

> when making is framed as being a set of practices, skills, and technologies to connect with one's community, young girls are likely to be initially motivated to engage in the maker activity, persist through construction challenges, and to show interest in further exploring making and technology. (p. 33)

Support for this is offered by Potvin and Hasni (2014) who completed a literature review of twelve years of educational research on science and technology. They describe an increase in interest, motivation and attitude towards science and technology when activities "can be linked to reality" (p. 98). Holbert (2016) comments on the effectiveness of Project Based Service Learning in attracting women to engineering and found that "women makers are driven by a desire to help and give back to their communities" (p. 33). Designing activities that require students to work together to solve a problem in the community would contribute to makerspace continuance by meeting the need of relatedness.

To aid in meeting student needs of autonomy and competence, activities should start with concepts, tools and techniques that they are familiar with. Blikstein (2013) recommends building on what users already know, and Kafai et al. (2014) endorse learning about technology through a medium that is comfortable. Considering once more the work of Vossoughi et al. (2016), educators should ask themselves how a marginalized group, such as female students, is already making, rather than assuming that they aren't makers and "designing activities based on dominant cultural norms and then working to broaden participation" (p. 218). It is important to understand that familiarity is only the starting point, and that the problems that students are solving can and should lead them to try new tools and develop new skills. When working with girls, Erikson et al. (2018) first hooked them with their personal interests, and began with familiar skills, but recognized that they needed to "give them an opportunity to continue working with technology and to support their knowledge progression to help them keep this newfound interest" (p. 13). By carefully designing activities that are based on familiar interests and formats, educators can provide students with opportunities to gain the competence and autonomy needed to tackle new challenges, which need to be offered as the learning progresses.

An educational makerspace often hosts activities outside of classroom hours and studies performed during voluntary workshops can inform practices to promote equity during extracurricular activities. Although girls may be required to use a makerspace during class, extracurricular making is voluntary and could therefore lead to inequitable access. Working to meet the basic needs of users becomes even more important during these activities, as makerspace continuance is now an actual choice for each student. Bean et al. (2015) argue that planning events specifically for women in community makerspaces would allow women who are interested in making to socialize and "could also make the space seem less male-dominated" (p. 66). Erikson et al. (2018) are also proponents of girl only workshops as they observed "a higher interest from girls to attend if boys are not invited" (p. 12). Activities that work to establish and encourage social interactions among girls would meet the need of relatedness and increase makerspace continuance.

Erikson et al. (2018) shared that when organizing specific events, the topic and how it is described are very important. They found that if trying to attract girls to an event, it is better to promote the fabrication element rather than any programming elements, even if programming is involved in the project. Specifically, they mention that any fabrication with light up elements attracted girls. The popularity of e-textile projects, which involve sewing microcontrollers on fabric and connecting them to lights and sensors with conductive thread, has also been studied by Kafai et al. (2014) and found to be very effective in diversifying makerspaces. Creating e-textiles is a way to build feelings of competence for users with different backgrounds. Those who already sew are able to demonstrate their skills to peers, are motivated to learn programming to complete their project, and are proud of developing that new skill. Conversely, those who already know how to program share this skill with peers, are motivated to learn how to sew, and proud of their new skills (Kafai et al., 2014). The basic need of competence is met, leading to an increase in maker continuance.

The concept of equity means that encouraging girls to use makerspaces does not need to be at the expense of including and supporting boys. Potvin and Hasni (2014) have encouragement for educators in this regard. Their research established that approaches favouring interest, motivation and attitude towards science and technology for girls, also provide increases for boys, bringing to mind the notion that while certain elements are necessary or essential for some, they are, nonetheless beneficial

for all.

Means

In the makerspace framework created by Hira et al. (2018), the means aspect includes tools, technology, supplies and skills. It is directly related to the purpose, but in the case of an educational makerspace the tools and technology should be dictated by the requirements of the activities that have been carefully created to promote equity. Martin (2015) warns of the potential dangers of focusing too heavily on tools and technology in an educational makerspace, He cautions against

> a seductive, but fatally flawed conceptualization of the Maker Movement that assumes its power lies primarily in its revolutionary tool set, and that these tools hold the power to catalyze transformations in education. Given the growing enthusiasm for making, there is a distinct danger that its incorporation into school settings will be toolcentric and thus incomplete. (p. 37)

In their manual for establishing a makerspace in a school, Hlubinka et al. (2013) state that "a collection of tools does not define a makerspace. Rather, we define it by what it enables: making". This further stresses the importance of focusing on the purpose of the space when choosing tools and technology.

Bean et al. (2015) learned that a "loud and messy workplace" (p. 66) was a barrier to participation for women in community makerspaces. Purchasing ear protection and tools to enable clean up would help eliminate this barrier, showing how the means aspect can contribute to the purpose of the space.

Skills cannot be discussed in isolation of the users who possess them, and call to mind once again the idea of makerspace continuance. As mentors, teachers and students develop skills and share them with each other while using the space, their basic need of competence will be met. Han et al. (2017) report that competence had the highest level of influence on motivation, and that technical support must happen in a collaborative atmosphere in order for it to be effective and impact competence. This means that both skill development and opportunities to collaborate are an important consideration for educational makerspaces.

A final consideration for the means aspect of a makerspace is the financial commitment that is required. Han et al. (2017) discuss the effect of economic support on users' feelings of autonomy and

competence, explaining that the freedom to make mistakes without assuming additional personal costs, leads a user to try more things on their own, which in turn, helps them to improve their skills. It follows, that an educational makerspace needs to have a generous supply of low-cost materials for prototyping and a variety of tools and technology available to its users if their needs of autonomy and competence are to be met.

Conclusion

By acknowledging the interconnectedness of the purpose, people, activities and means, proposed in the framework for educational makerspaces, educators can begin to examine how careful consideration of these aspects can play a role in promoting gender equity. Students and teachers who have access to educational makerspaces will be intrinsically motivated to continue using the space if their psychological needs for autonomy, competence and relatedness are met. Educators can help meet these needs by procuring community members to act as mentors, and hosting girl only activities that focus on fabrication rather than programming. However, educators require training and support in order to meet their own psychological needs, and to fully realize their potential impact on students' perception and use of technology, as well as future career possibilities. Current research recommends basing activities on learners' interests, framing them in reality and starting from a place of familiarity. The means should not be the focus of an educational makerspace, but rather the tools, materials and skills should be dictated by the needs of the people and the requirements of the activities.

The lack of research into gender and making cited in this paper, necessitated a synthesis of research from these two separate fields in order to gain an understanding of factors that may affect gender equity in educational makerspaces. In order to further current understanding of how to best engage and support female students in their use of makerspaces, additional empirical studies are needed. Possible areas of study include comparing barriers to female participation in educational makerspaces with community makerspaces; the relationship between the gender of the mentor and/or teacher and its impact on female participation; and the design and layout of the physical space on makerspace continuance in females. Finally, there is a need for long term studies to determine if promoting gender equity in educational makerspaces

has an impact on the gender gap in community makerspaces and STEM related careers.

REFERENCES

Allegrini, A. (2015). Gender, STEM Studies and Educational Choices. Insights from Feminist Perspectives. In E. Henriksen, J. Dillon, J. Ryder (Eds.), Understanding Student Participation and Choice in Science and Technology Education (pp. 43-59). doi: 10.1007/978-94-007-7793-4_4

Ardies, J., De Maeyer, S., & Gijbels, D. (2014). Students attitudes towards technology. International Journal of Technology and Design Education, 25(1), 43-65. doi: 10.1007/s10798-014-9268-x

Bean, V., Farmer, N. M., & Kerr, B. A. (2015). An exploration of women's engagement in Makerspaces. Gifted and Talented International, 30, (1-2), 61-67. doi: 10.1080/15332276.2015.1137456

Blikstein, P. (2013). Digital Fabrication and 'Making' in Education: The Democratization of Invention. FabLabs: Of Machines, Makers and Inventors, 1 - 21.

Cai, Z., Fan, X., & Du, J. (2017). Gender and attitudes toward technology use: A meta-analysis. Computers & Education, 105, 1-13. doi: 10.1016/j.compedu.2016.11.003

Chu, S.L., Angello, G., Saenz, M., & Quek, F. (2017). Fun in Making: Understanding the experience of fun and learning through curriculum-based Making in the elementary school classroom. Entertainment Computing, 18, 31-40. doi: 10.1016/j.entcom.2016.08.007

Cohen, J., Huprich, J., Jones, W., & Smith, S. (2017). Educators' perceptions of a maker-based learning experience. The International Journal of Information and Learning Technology, 34(5), 428-438. doi: 10.1108/IJILT-06-2017-0050

Eriksson, E., Heath, C., Ljungstrand, P., & Parnes, P. (2018). Makerspace in school - Considerations from a large-scale national testbed. International Journal of Child-Computer Interaction, 16, 9-15. doi: 10.1016/j.ijcci.2017.10.001

Faulkner, S. (2014). Women who make: Undercounted as Makers and underwhelmed by Makerspaces. Computer, 47(12), 30–31. doi:10.1109/MC.2014.373

Faulkner, S., & McClard, A. (2014). Making Change: Can Ethnographic Research about Women Makers Change the

Future of Computing? Ethnographic Praxis in Industry Conference Proceedings, 2014(1), 187-198.

Han, S., Yoo, J., Zo, H., & Ciganek, A.P. (2017). Understanding makerspace continuance: A self-determination perspective. Telematics and Informatics, 34(4), 184-195. doi: 10.1016/j.tele.2017.02.003

Hira, A., Hynes, M., & Szalay, P. (2018). People, means, and activities: A conceptual framework for realizing the educational potential of Makerspaces. Education Research International, 10. doi: 10.1155/2018/6923617

Holbert, N. (2016). Leveraging cultural values and "ways of knowing" to increase diversity in maker activities. International Journal of Child-Computer Interaction, 9-10, 33-39. doi: 10.1016/j.ijcci.2016.10.002

Hughes, J. (2017). Digital making with "At-Risk" youth. The International Journal of Information and Learning Technology, 34(2), 102-113. doi: 10.1108/IJILT-08-2016-0037

Hyde, J. (2016). Sex and cognition: Gender and cognitive functions. Current Opinion in Neurobiology, 38, 53-56. doi: 10.1016/j.conb.2016.02.007

Intel/Harris Poll. (2014). MakeHers: Engaging girls and women in technology through making, creating, and inventing. Retrieved from http://www.intel.com/content/dam/www/public/us/en/documents/reports/Makers-report-girls-women.pdf

Johnson, L., Adams-Becker, S., Estrada, V. & Freeman, A. (2015). NMC Horizon Report: 2015 K-12 Edition, The New Media Consortium, Austin, TX. Retrieved from http://cdn.nmc.org/media/2015-nmc-horizon-report-k12-EN.pdf

Kafai,Y., Fields, D., & Searle, K. (2014). Electronic textiles as disruptive designs: Supporting and challenging maker activities in schools. Harvard Educational Review, 84(4), 532–556.

Kurti, R.S., Kurti, D.L., & Fleming, L., (2014). The philosophy of educational makerspaces: Part 1 of Making an Educational Makerspace. Teacher Librarian, 41(5), 8-11.

Martin, L. (2015). The promise of the maker movement for education. Journal of Pre-College Engineering Education Research (J-PEER), 5(1), 30-39. doi: http://dx.doi.org/10.7771/2157-9288.1099

Noh, Y. (2017). A study of the effects of library creative zone programs on creative thinking abilities. Journal of

Librarianship and Information Science, 49(4), 380-396. doi: 10.1177/0961000616650933

Papavlasopoulou, S., Giannakos, M. N., & Jaccheri, L. (2017). Empirical studies on the Maker Movement, a promising approach to learning: A literature review. Entertainment Computing, 18, 57-78. doi: 10.1016/j.entcom.2016.09.002

Petrich, M., Wilkinson, K., & Bevan, B. (2013). It looks like fun, but are they learning? In M. Honey & D. Kanter (Eds.), Design, make, play: Growing the next generation of STEM innovators (pp. 50-70). New York: Routledge.

Potvin, P., & Hasni, A. (2014). Interest, motivation and attitude towards science and technology at K-12 levels: A systematic review of 12 years of educational research. Studies in Science Education, 50(1), 85-129. doi: 10.1080/03057267.2014.881626

Reilly, D. (2012). Gender, culture, and sex-typed cognitive abilities. PLoS One, 7(7), 1-16. doi: 10.1371/journal.pone.0039904

Sadler, P., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. Science Education, 96(3), 411-427. doi: 10.1002/sce.21007

Smith, R., Iversen, O., & Veerasawmy, R. (2016). Impediments to digital fabrication in education: A study of teachers' role in digital fabrication. International Journal of Digital Literacy and Digital Competence, 7(1), 33-49. doi: 10.4018/IJDLDC.2016010103.

Vekiri, I. (2010). Boys' and girls' ICT beliefs: Do teachers matter? Computers & Education, 55(1), 16-23. doi: 10.1016/j.compedu.2009.11.013

Vossoughi, S., Hooper, P. K., & Escudé, M. (2016). Making through the lens of culture and power: Toward transformative visions for educational equity. Harvard Educational Review, 86(2), 206-232,307-309.

Wajcman, J. (2010). Feminist theories of technology. Cambridge Journal of Economics, 34(1), 143-152. doi: 10.1093/cje/ben057

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